OPTICAL MEMORY TECHNOLOGY REVIEW

JUNE 11 – 12 1986

PRESENTATION MATERIAL
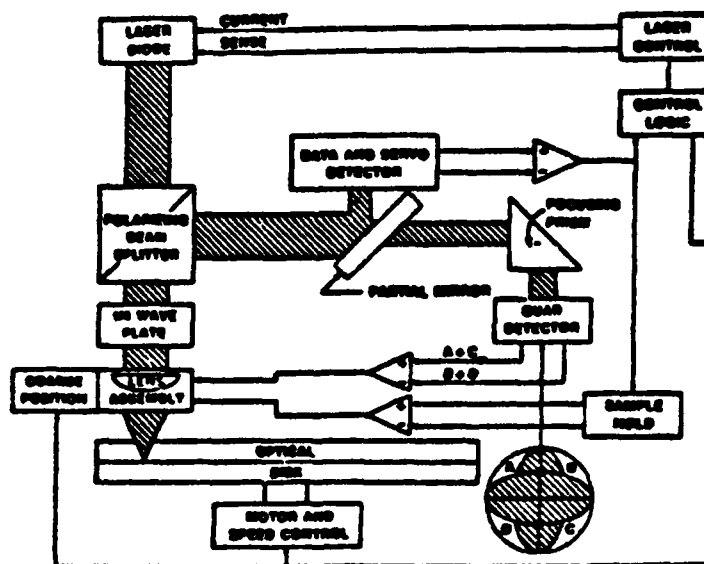
VOLUME 1 OF 3

OPTICAL MEMORY TECHNOLOGY REVIEW

June 11 - 12, 1986

Organized by the Naval Air Development Center

Hosted by the National Bureau of Standards

The Optical Memory Technology Review (OMTR) was held at the National Bureau of Standards, in Gaithersburg, Maryland, on June 11, from 9:00 am to 6:00 pm and at the Gaithersburg Marriott, in Gaithersburg, Maryland, on June 12, from 8:30 am to 3:00 pm. Enclosed are the OMTR agenda and the presentation materials from one-half of the June 11 afternoon OMTR session.

Materials from the "US Department of Defense Sponsored Optical Disk Studies" as they were presented in the morning session on June 11 are not included, since that session was for employees of the Federal sector, only. Overveiws of the "US Department of Defense Sponsored Optical Disk Studies", as they were presented to members of both the Federal and private sectors, in the June 11 afternoon session are included in this "Section 1" and also in "Section 2", which has been mailed to you under separate cover.

"Section 2" contains the presentation materials from speakers in the second-half of the June 11 afternoon session. Also mailed under separate cover, is "Section 3", which contains the presentation materials from the June 12 session, in addition to the list of OMTR participants.

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i.

October 1, 1986

Dear Optical Memory Technology Review Participant:

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Publication of these materials does not constitute approval by the Naval
Air Development Center or the National Bureau of Standards of the findings
or conclusions contained herein. These materials are published by the
Naval Air Development Center for the exchange and stimulation of ideas.

The objective of the OMTR was to provide a forum for discussion on
optical storage technology and its applications in the US Department of
Defense and Federal government. Thank you for your participation.

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OPTICAL MEMORY TECHNOLOGY REVIEW

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Session 1   (FEDERAL GOVERNMENT EMPLOYEES ONLY)

                 June 11, 1986
                 9:00 a.m. - 12:30 p.m.

                 Green Auditorium
                 Administration Building
                 National Bureau of Standards
                 Gaithersburg, Maryland

Session 2   (FEDERAL GOVERNMENT AND INDUSTRY EMPLOYEES)

                 June 11, 1986
                 1:30 p.m. - 6:00 p.m.

                 Green Auditorium
                 Administration Building
                 Naitonal Bureau of Standards
                 Gaithersburg, Maryland

Sessions 3 & 4   (FEDERAL GOVERNMENT AND INDUSTRY EMPLOYEES)

                 June 12, 1986
                 8:30 a.m. - 3:00 p.m.

                 Gaithersburg Marriott
                 620 Lakeforest Avenue
                 SALONS A, B, C and D
                 Gaithersburg, Maryland

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iii.

AGENDA
OPTICAL MEMORY TECHNOLOGY REVIEW
NATIONAL BUREAU OF STANDARDS
GREEN AUDITORIUM, ADMINISTRATION BUILDING
GAITHERSBURG, MARYLAND

SESSION 1

SESSION 1 IS FOR FEDERAL GOVERNMENT EMPLOYEES ONLY

REGISTRATION FOR SESSION 1 BEGINS AT 8:15 AM

SESSION 1 : Wednesday, June 11, 1986 9:00 am - 12:30 pm

MODERATOR: Roman Fedorak, Naval Air Development Center

9:00 am   Department of Defense Sponsored Optical Disk Study (Fairchild)

10:15 am   BREAK

10:45 am   Department of Defense Sponsored Optical Disk Study (Sperry)

12:30 pm   END OF SESSION 1

               LUNCH

SESSION 2

SESSION 2 IS FOR FEDERAL GOVERNMENT AND INDUSTRY EMPLOYEES

REGISTRATION FOR SESSION 2 BEGINS AT 12:00 PM

SESSION 2 : Wednesday, June 11, 1986 1:30 pm - 6:00 pm

MODERATOR: Roman Fedorak, Naval Air Development Center

1:30 pm   Welcoming Remarks: Raymond Kammer
                                  Deputy Director
                                  National Bureau of Standards

              Organizer's Comments: Roman Fedorak
                                     Naval Air Development Center

1:50 pm   Keynote Speaker: John Riganati
                               Director, System Research
                               Supercomputing Research Center
                               Institute for Defense Analyses
              "US High Technology Industry, Its Principles
              and Challenges...With an Emphasis on the Optical Digital
              Data Disk (OD3) Challenge"

2:10 pm   "Storage Requirements and Applications"
              Bernie Zempolich
              Naval Air Systems Command

2:40 pm   "Status of 5.25-inch Optical Digital Data Disk Technology"
              Di Chen
              Optotech

3:00 pm   BREAK

SESSION 2, OPTICAL MEMORY TECHNOLOGY REVIEW (AGENDA)

3:30 pm   "Interpretation of US Department of Defense Specifications
                   for Device Designers"
                   Marc Saltzman
                   Fairchild Communications and Electronics Company

3:50 pm   Overview of Two DOD Sponsored 5.25-inch Optical Disk
                   Studies:

                   "Optical Memory System Study Presentation"
                   Tim Rogers
                   Fairchild Communications and Electronics Company

                   "Optical Disk Study Overview"
                   Dave Zempke
                   Sperry Corporation

5:00 pm   "Portable Optical Memory Systems for Tactical Applications"
                   Robert Miller
                   US Army Electronics Laboratory

5:20 pm   "Overview of DOD/NASA Large Optical Disk Systems Development"
                   Jack D. Petruzelli
                   US Air Force

5:40 pm   "Digital Map Generation"
                   Lt. Col. Milton Cone
                   US Defense Mapping Agency

6:00 pm   END OF SESSION 2

OPTICAL MEMORY TECHNOLOGY REVIEW
GAITHERSBURG MARRIOTT
GAITHERSBURG, MARYLAND

SESSION 3

SESSION 3 IS FOR FEDERAL GOVERNMENT AND INDUSTRY EMPLOYEES

REGISTRATION FOR SESSIONS 3 AND 4 BEGINS AT 8:00 AM

SESSION 3 : Thursday, June 12, 1986 8:30 am - 12:45 pm

MODERATOR : Jean Freedman, National Bureau of Standards

8:30 am	"Overview of Magnetic Disk Technology," Ron Lares Control Data Corporation
	"Overview of Magnetic Disk Technology" Bryan Birch Miltope Corporation
9:10 am	"Federal Interest, Requirements, and Plans For Optical Disk Technology...As Told To The Federal Council on Computer Storage Standards and Technology" Jean Freedman National Bureau of Standards
9:20 am	"Optical Memory Recording Concepts and Current Commercialization Trends" Leonard Laub Vision Three
10:15 am	BREAK

SESSION 3, OPTICAL MEMORY TECHNOLOGY REVIEW (AGENDA)

10:45 am   Presentations and Panel Discussion:
"Overview of Optical Digital Data Disk
Research and Development"

PANEL DISCUSSION MODERATOR: Leonard Laub

"Overview of Optical Digital Data
Disk Research and Development"
John Morgan
Philips and DuPont Optical Company

"Overview of Optical Digital Data
Disk Research and Development"
Gerald Poshkus
Eastman Kodak Company

"Overview of Optical Digital Data
Disk Research and Development"
Roger Hilde
3M Company

"Overview of Optical Digital Data
Disk Research and Development
Bryan Birch
Miltope Corporation

12:45 p.m.   END OF SESSION 3

LUNCH

AGENDA
OPTICAL MEMORY TECHNOLOGY REVIEW
GAITHERSBURG MARRIOTT
GAITHERSBURG, MARYLAND

SESSION 4

SESSION 4 IS FOR FEDERAL GOVERNMENT AND INDUSTRY EMPLOYEES

SESSION 4   :   June 12, 1986   1:45 pm - 3:00 pm

MODERATOR: Jean Freedman, National Bureau of Standards

1:45 pm   "Optical Digital Data Disk System Components...The Status of
                 Research and Development"
                 Oliver Bessette
                 RCA Corp.

2:10 pm   "Overview of the National Space Science Data Center; Optical
                 Disk System Integration "
                 Brian Lopez-Swafford
                 National Aeronautics and Space Administration

2:30 pm   "Issues in Optical Disk Longevity and Approaches to Optical
                 Disk Life Testing"
                 William Nugent
                 Library of Congress

2:50 pm   "Summary of the Presentations and Discussions from the
                 June 11 and 12, 1986, OPTICAL MEMORY TECHNOLOGY REVIEW"
                 Leonard Laub
                 Vision Three

3:00 pm   END OF SESSION 4

OPTICAL MEMORY TECHNOLOGY REVIEW

June 11 - 12, 1986

ORGANIZED BY THE NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

HOSTED BY THE NATIONAL BUREAU OF STANDARDS, GAITHERSBURG, MD

Held at the National Bureau of Standards, Gaithersburg, Maryland
and the Gaithersburg Marriott, Gaithersburg, Maryland

TABLE OF CONTENTS: "SECTION 1"

PRINCIPLE 0

THE PRIMARY PURPOSE OF A CORPORATION
BASED ON HIGH TECHNOLOGY IS TO MOVE
TECHNOLOGY INTO THE MARKETPLACE.

Figure 1. "US High Technology Industry, Its Principles and Challenges. . . . With An Emphasis on the Optical Digital Data Disk (OD^3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.
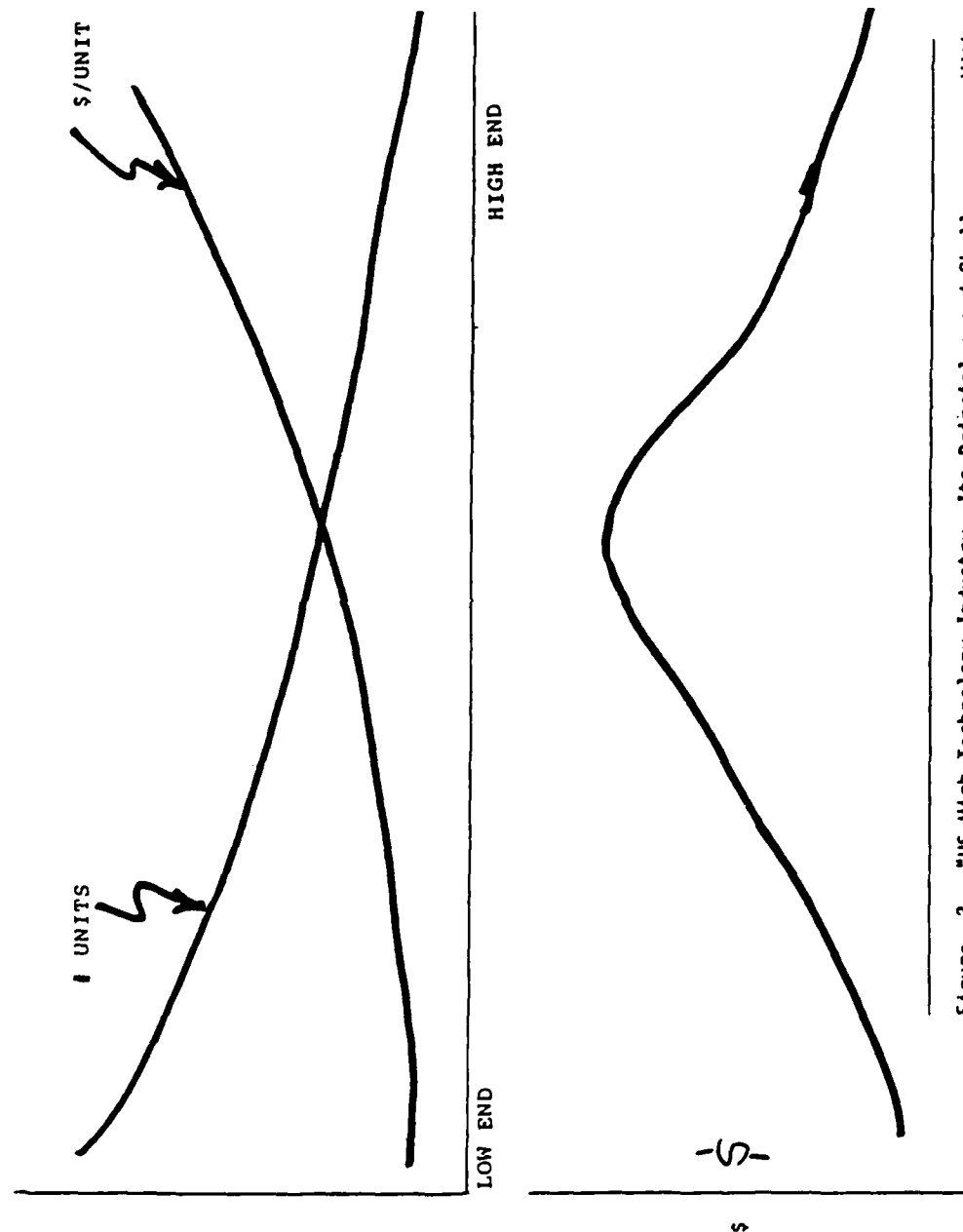
A NORMAL MARKETPLACE

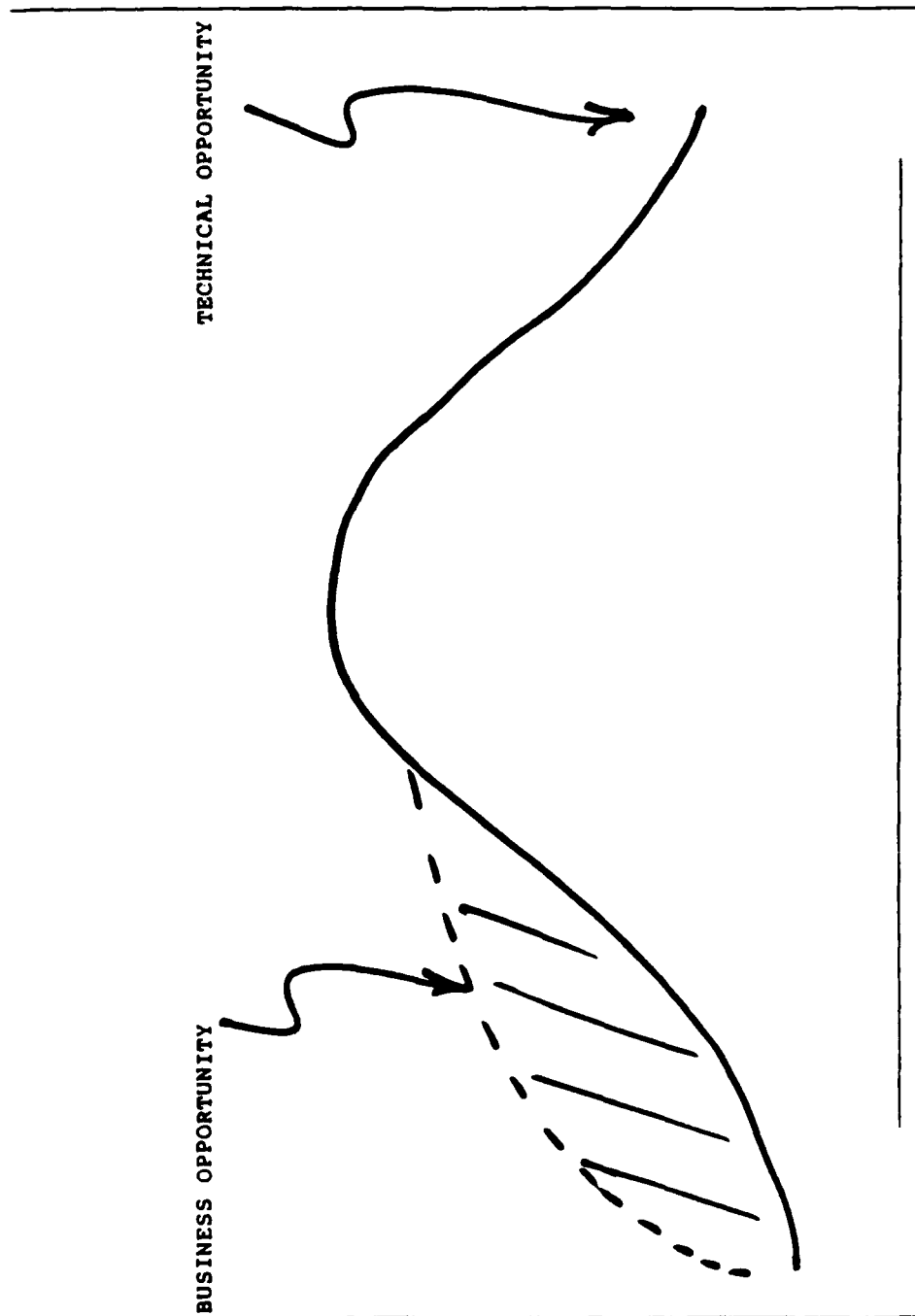$/UNIT

UNITS

LOW END

HIGH END

$

-$-

Figure 2. "US High Technology Industry, Its Principles and Challenges...", With An Emphasis on the Optical Digital Data Disk (OD³) Challenge"; John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

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OPTICAL DIGITAL DATA DISK MARKETPLACE

Figure 3. "US High Technology Industry, Its Principles and Challenges.. . With An Emphasis on the Optical Digital Data Disk (OD3) Challenge", John Riyanati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.
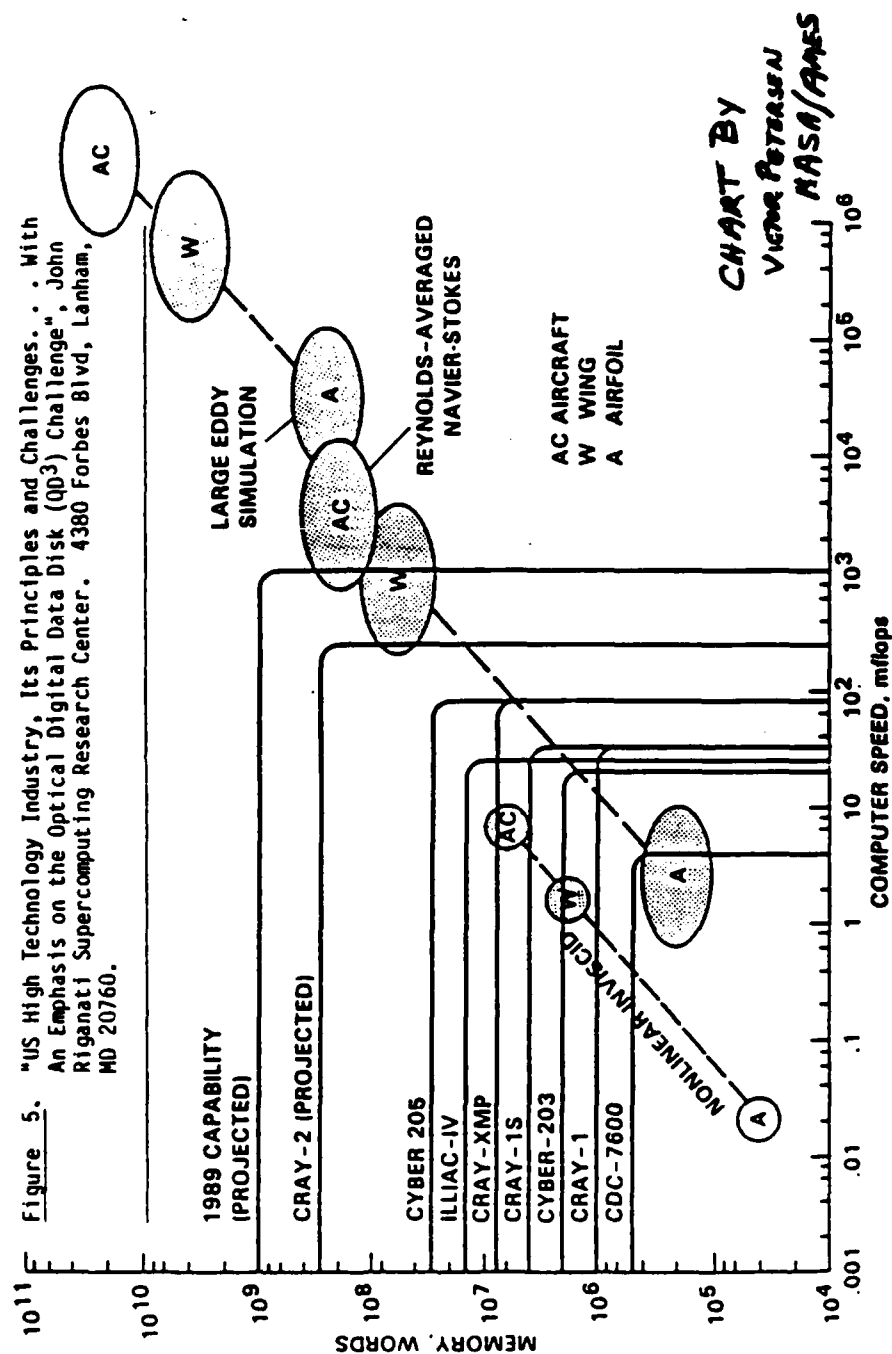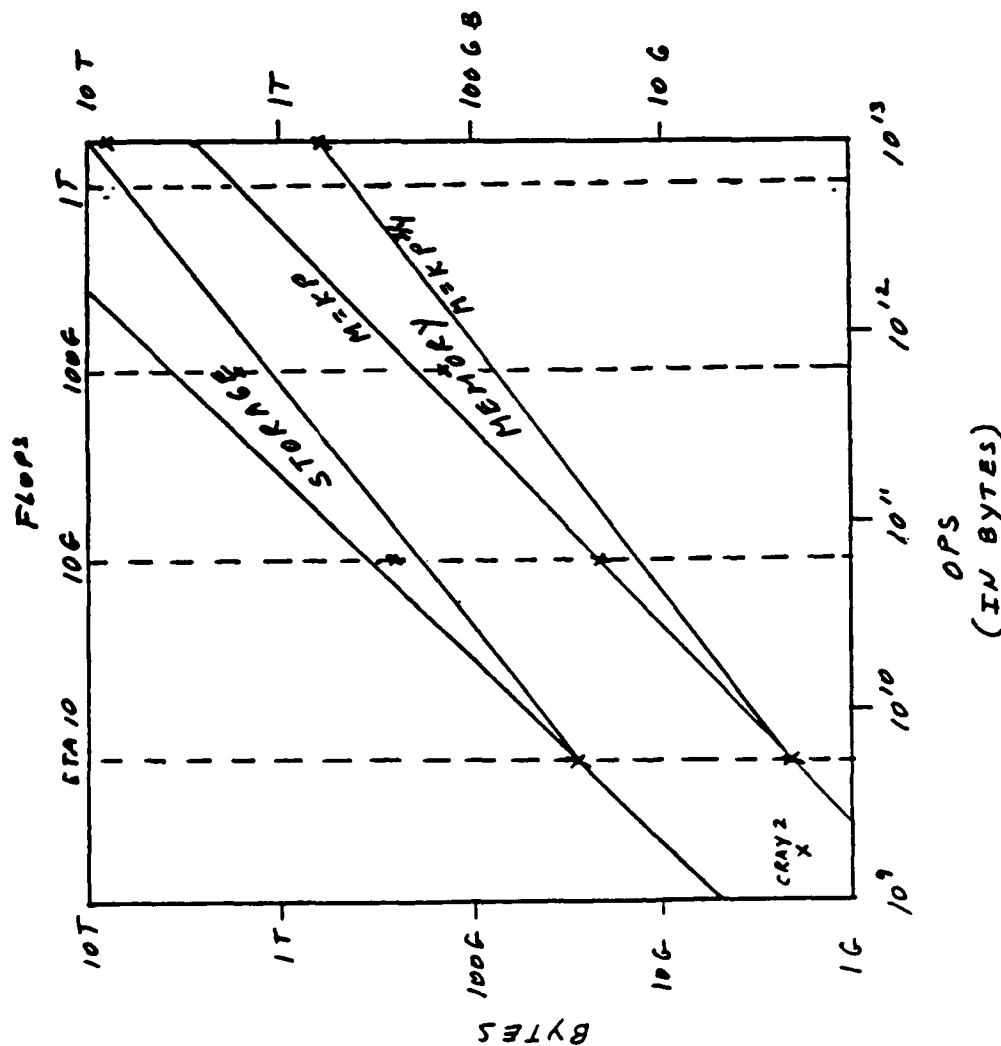
OMTR/3

THERE ARE TWO KINDS OF INVENTION

1. GIVEN A GOAL, FIND A MEANS TO
   REACH IT,

2. DISCOVER A FACT, IMAGINE WHAT IT
   COULD BE USED FOR.

Figure 4. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (OD3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

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COMPUTATIONAL AERODYNAMICS
COMPUTER SPEED AND MEMORY REQUIREMENTS
COMPARED WITH COMPUTER CAPABILITIES
.15-min. RUNS WITH 1985 ALGORITHMS

Figure 5. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (QD³) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

1989 CAPABILITY (PROJECTED)

CRAY-2 (PROJECTED)

CYBER 205
ILLIAC-IV
CRAY-XMP
CRAY-1S
CYBER-203
CRAY-1
CDC-7600

LARGE EDDY SIMULATION

REYNOLDS-AVERAGED NAVIER-STOKES

AC AIRCRAFT
W WING
A AIRFOIL

NONLINEAR INVISCID

CHART BY VICTOR PETERSEN NASA/AMES

OMTR/5

Figure 6. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (OD)3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

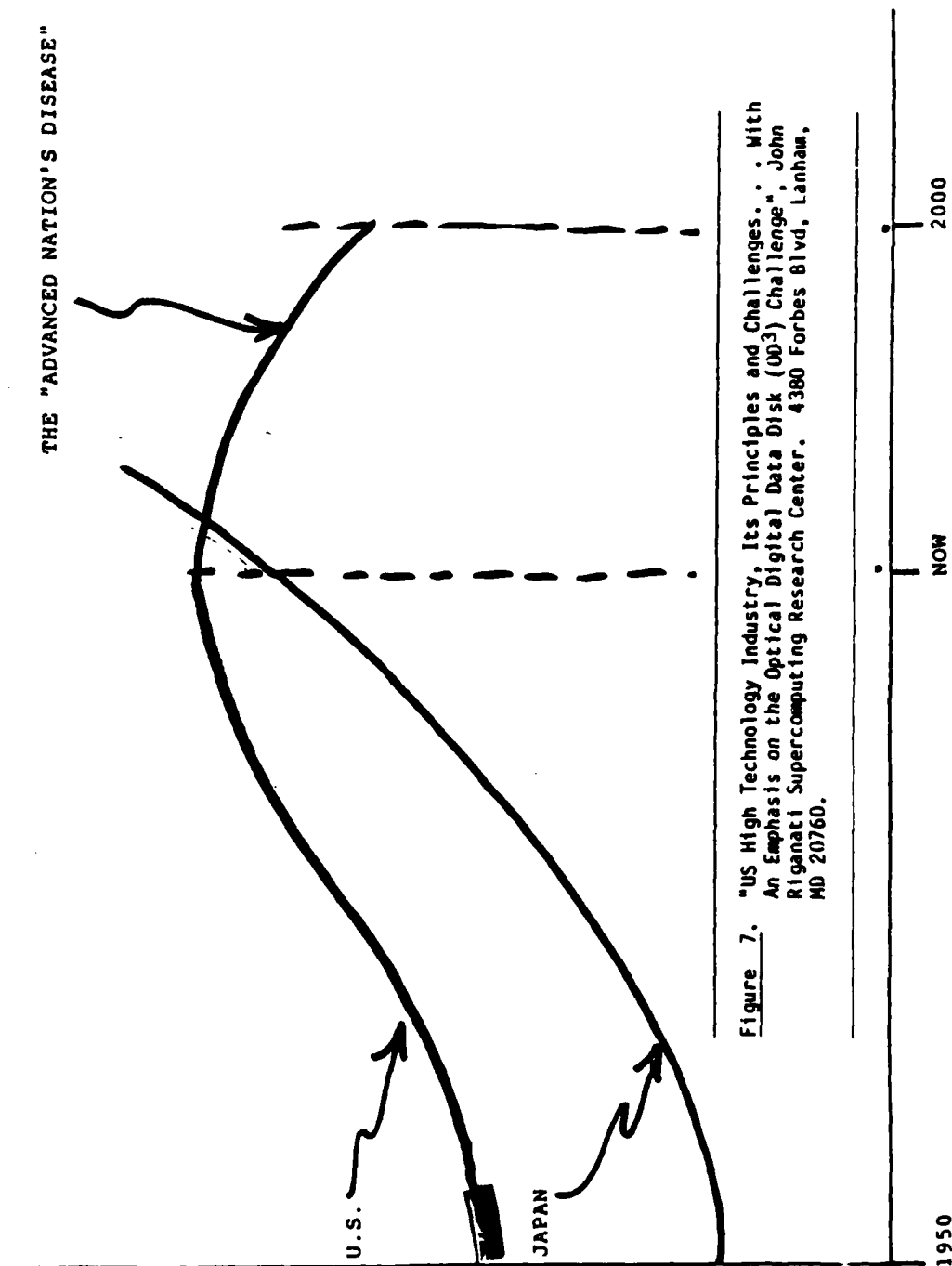# A JAPANESE PROJECTION

THE "ADVANCED NATION'S DISEASE"

U.S.

JAPAN

1950   NOW   2000

Figure 7. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (OD^3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.
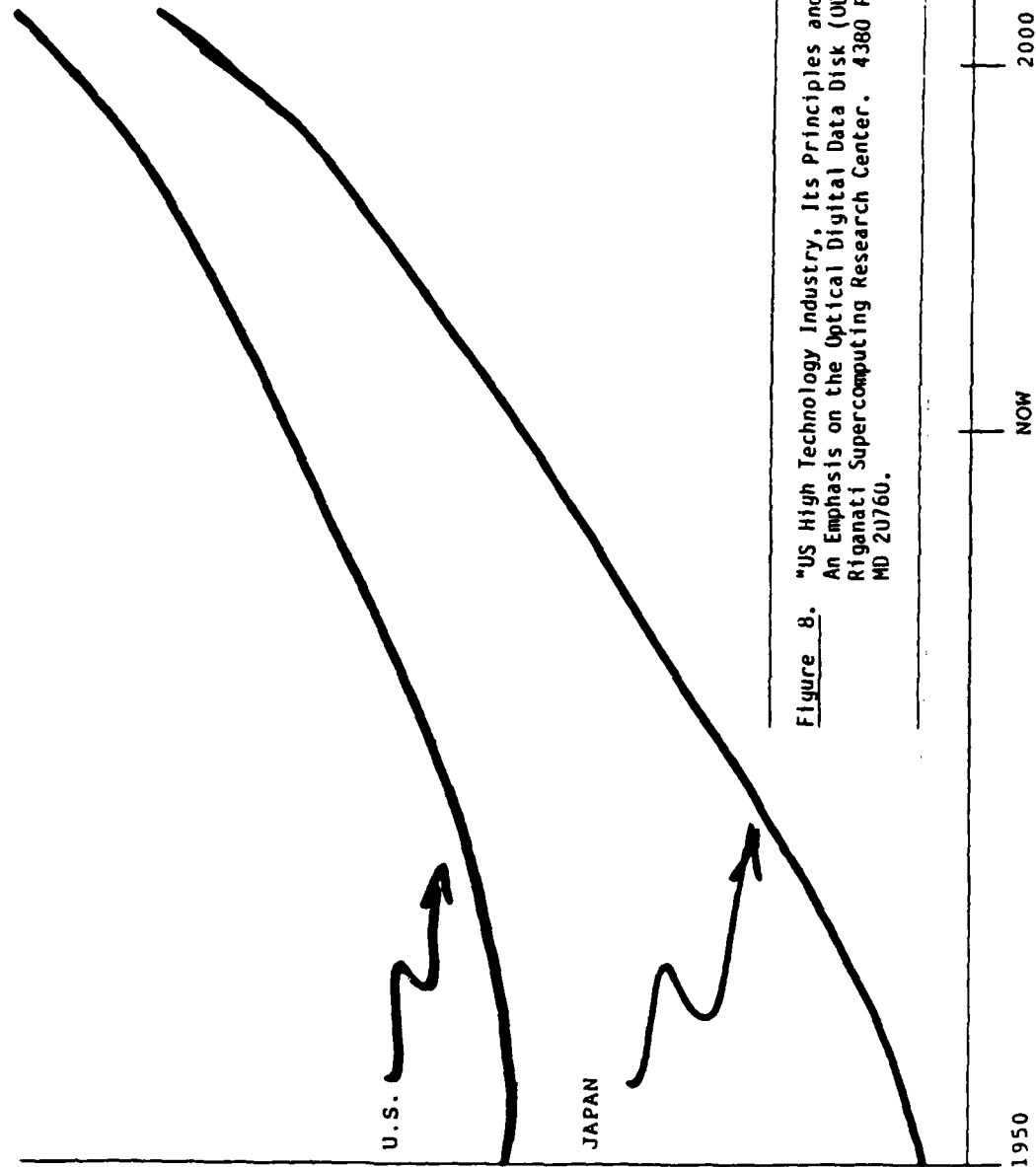
A "HEALTHIER" PROJECTION

Figure 8. "US High Technology Industry, Its Principles and Challenges.. ., With An Emphasis on the Optical Digital Data Disk (UD3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

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RELATIONSHIP OF QUALITY TO HIGH TECHNOLOGY IN JAPAN

- W. EDWARDS DEMING'S 1950 MESSAGE FOR JAPAN:

  IMPROVED QUALITY ⟶ IMPROVED PRODUCTIVITY & DECREASED COST

- QUALITY **IS** HIGH TECHNOLOGY

Figure 9. "US High Technology Industry, Its Principles and Challenges. . . With An Emphasis on the Optical Digital Data Disk (OD3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

OMTR/9

DEMING'S SEVEN DEADLY DISEASES

1). LACK OF CONSTANCY OF PURPOSE

2). SHORT TERM THINKING

3). MANAGEMENT BY OBJECTIVES
   - NOURISHES SHORT TERM THINKING
   - ANNIHILATES LONG TERM PLANNING
   - DEMOLISHES TEAM WORK
   - BUILDS FEAR
   - CREATES BITTERNESS
   - ENCOURAGES MOBILITY

4). BARRIERS TO PRIDE OF WORKMANSHIP

5). FAILURE TO ADOPT A POLICY OF NEVER-ENDING IMPROVEMENT

6). HOPE FOR QUICK RESULTS (INSTANT PUDDING)

7). "BOTTOM LINE" FINANCIAL MANAGEMENT WITHOUT REGARD TO FIGURES THAT ARE UNKNOWN OR UNKNOWABLE

Figure 10. "US High Technology Industry, Its Principles and Challenges. . . With An Emphasis on the Optical Digital Data Disk (OD³) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.
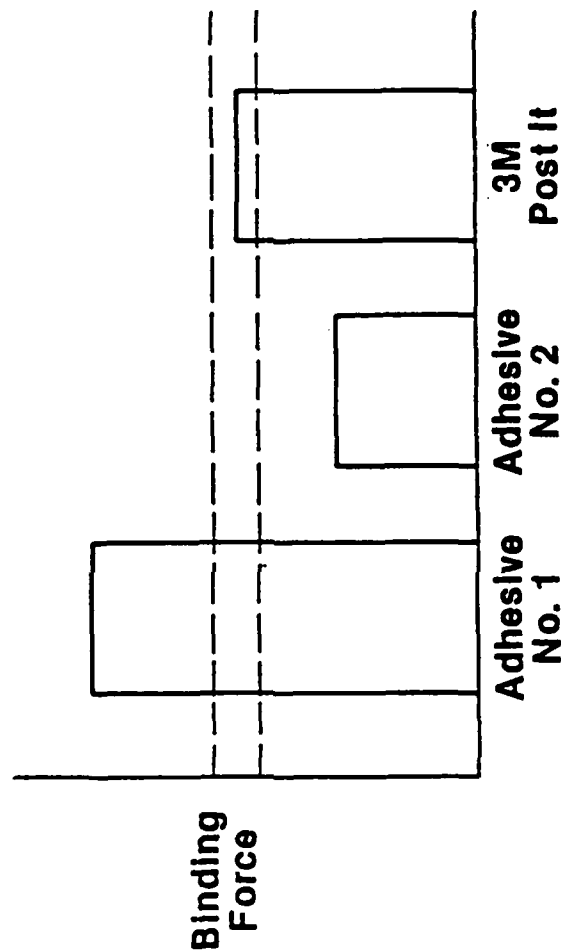
Serendipity vs the Lowest Bidder

Figure 11. "US High Technology Industry, Its Principles and Challenges.. . With An Emphasis on the Optical Digital Data Disk (On3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

LATENT BENEFITS OF CONSENSUS PROCESSES

- THE HISTORY OF TECHNOLOGY IS THE HISTORY OF THE BIRTH, WEANING, AND (MOSTLY) DEATH OF IDEAS.

- THERE ARE TWO TYPES OF IDEAS:

  - RADICAL NEW IDEAS; AND

  - IDEAS WHOSE TIME HAS COME.

Figure 12. "US High Technology Industry, Its Principles and Challenges.. . With An Emphasis on the Optical Digital Data Disk (OD3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

LATENT BENEFITS OF CONSENSUS PROCESSES (CONTINUED)

● FOR IDEAS WHOSE TIME HAS COME, PROPERLY EXECUTED CONSENSUS PROCESSES CAN SUBSTANTIALLY IMPROVE THEIR PROBABILITY OF SURVIVAL.

● IN THE UNITED STATES, CONSENSUS PROCESSES ARE MOST COMMONLY CARRIED OUT BY STANDARDIZATION GROUPS.

Figure 13. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (OD3) Challenge". John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

LATENT BENEFITS OF CONSENSUS PROCESSES
(CONTINUED)

● UNFORTUNATELY, THERE ARE TWO TYPES OF
STANDARDIZATION:

— BUREAUCRATIC STANDARDIZATION
(WHICH STULTIFIES GROWTH); AND

— CONSENSUS-BASED STANDARDIZATION
(WHICH ENABLES GROWTH).

● ANY ACTION BASED ON CONSENSUS
REQUIRES ALL PARTICIPANTS TO
UNDERSTAND NOT ONLY THE OPPOSING
VIEWS BUT THE TECHNICAL, BUSINESS, OR
SOCIOLOGICAL REASONS FOR THOSE VIEWS.

Figure 14. "US High Technology Industry, Its Principles and Challenges... . With
An Emphasis on the Optical Digital Data Disk (OD3) Challenge", John
Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham,
MD 2U760.

SUMMARY OF PRINCIPLES

0. THE PRIMARY PURPOSE OF CORPORATE ACTIVITY IN HIGH TECHNOLOGY IS TO MOVE TECHNOLOGY INTO THE MARKET-PLACE.

I. DESPITE PRINCIPLE ▢, PRAGMATIC MANAGEMENT DECISIONS AT THIS TIME IN THESE UNITED STATES CAN ONLY BE BASED ON THE PATH OF LEAST RESISTANCE.

II. NATIONS RISE AND FALL. AS A HISTORICALLY YOUNG NATION, THE U.S. CAN BE STILL ON THE RISE IF WE REALLY BELIEVE THIS TO BE TRUE AND ACT ACCORDINGLY.

Figure 15. "US High Technology Industry, Its Principles and Challenges. . . . With An Emphasis on the Optical Digital Data Disk (OD³) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

SUMMARY OF PRINCIPLES
(CONTINUED)

III. TECHNOLOGICAL PROGRESS IS REAL.

IV. CONSENSUS PROCESSES CONTAIN LATENT BENEFITS WELL BEYOND STANDARDIZA-TION OF SPECIFICATIONS.

Figure 16. "US High Technology Industry, Its Principles and Challenges. . . With An Emphasis on the Optical Digital Data Disk (OD³) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

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SUMMARY OF CHALLENGES TO OD^3

0.   DON'T LET THE ACCOUNTANTS WEAR YOU DOWN.

I.   USE THE LOW END TO ADVANCE THE HIGH END!

II. DON'T BELIEVE THERE IS ANYTHING "JAPANESE" ABOUT GOOD MANAGEMENT PRACTICES.

Figure 17. "US High Technology Industry, Its Principles and Challenges... . With An Emphasis on the Optical Digital Data Disk (OD^3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

SUMMARY OF CHALLENGES TO OD^3
(CONTINUED)

III. CONSTANTLY EVALUATE: IS PROGRESS REAL?

IV. USE THE CONSENSUS PROCESS TO PURIFY IDEAS AS WELL AS SPECIFICA- TIONS.

Figure 18. "US High Technology Industry, Its Principles and Challenges...".With An Emphasis on the Optical Digital Data Disk (OD^3) Challenge", John Riganati Supercomputing Research Center. 4380 Forbes Blvd, Lanham, MD 20760.

RESEARCH & TECHNOLOGY
FOR NAVAL AVIATION
AIR-03

OPTICAL MEMORY

STORAGE REQUIREMENTS AND APPLICATIONS

FOR USE IN MILITARY ENVIRONMENTS

BERNARD A. ZEMPOLICH

NAVAL AIR SYSTEMS COMMAND

Figure 1. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

OMTR/19

NOTICE: THIS IS AN EDITED VERSION OF THE AUTHOR'S PRESENTATION

GIVEN AT THE NATIONAL BUREAU OF STANDARDS - NAVAL AIR DEVELOPMENT

CENTER OPTICAL DISK SYMPOSIUM. THE VIEWS AND OPINIONS EXPRESSED ARE

THESE OF THE AUTHOR'S AND NOT OFFICIAL POSITIONS OF THE NAVAL AIR SYSTEMS

COMMAND, THE DEPARTMENT OF THE NAVY, NOR THE DEPARTMENT OF DEFENSE. THE

MATERIAL DOES NOT CONTAIN THE PHOTOGRAPHS SHOWN DUE TO THE LACK OF TECHNICAL

CAPABILITY TO REPRODUCE THE PICTURES IN HARD COPY FORM. THE PROSE THAT

HAS BEEN ADDED IS FROM PREVIOUSLY PREPARED PRESENTATIONS THAT WERE CLEARED

FOR PUBLIC RELEASE.

Figure 2. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

MEMORY REQUIREMENT FOR TECHNICAL MANUALS ASSOCIATED WITH A CARGO-TYPE AIRCRAFT.

CURRENTLY THERE ARE 155 TECHNICAL MANUALS PUBLISHED FOR AND REQUIRED TO OPERATE AND

MAINTAIN ONE PARTICULAR CARGO AIRCRAFT. THE MANUALS CONSIST OF APPROXIMATELY 70,000

(SEVENTY THOUSAND) PAGES AND TOTAL WEIGHT IS 500 LBS. 124 CUBIC FEET OF SHELF SPACE

IS REQUIRED FOR STORAGE OF THE MANUALS.

THE FLIGHT MANUAL IS FLOWN ON BOARD EVERYDAY AND IS STORED ON THE FLIGHT DECK.

- THERE ARE 53 MANUALS ON THE FLIGHT DECK.

- TOTAL WEIGHT 200 LBS.

- CONTAINS 23,000 PAGES

- REQUIRES AT LEAST 50 CUBIC FEET OF SHELF SPACE FOR STORAGE ON FLIGHT DECK.

REVISIONS OVER A 10 YEAR PERIOD ARE APPROXIMATELY 140,000 PAGES APPROXIMATELY 14K/YEAR

450 WORDS/PAGE AVERAGE, 1170 SEPARATE, FORMAL CHANGES.

BY EXAMPLE, ONE HIGH PERFORMANCE FIGHTER AIRCRAFT HAS APPROXIMATELY 7,000,000 PAGES OF DOCUMENTATION

ASSOCIATED WITH IT IN THE OPERATIONAL ENVIRONMENT.

"TRANSLATION FACTOR"

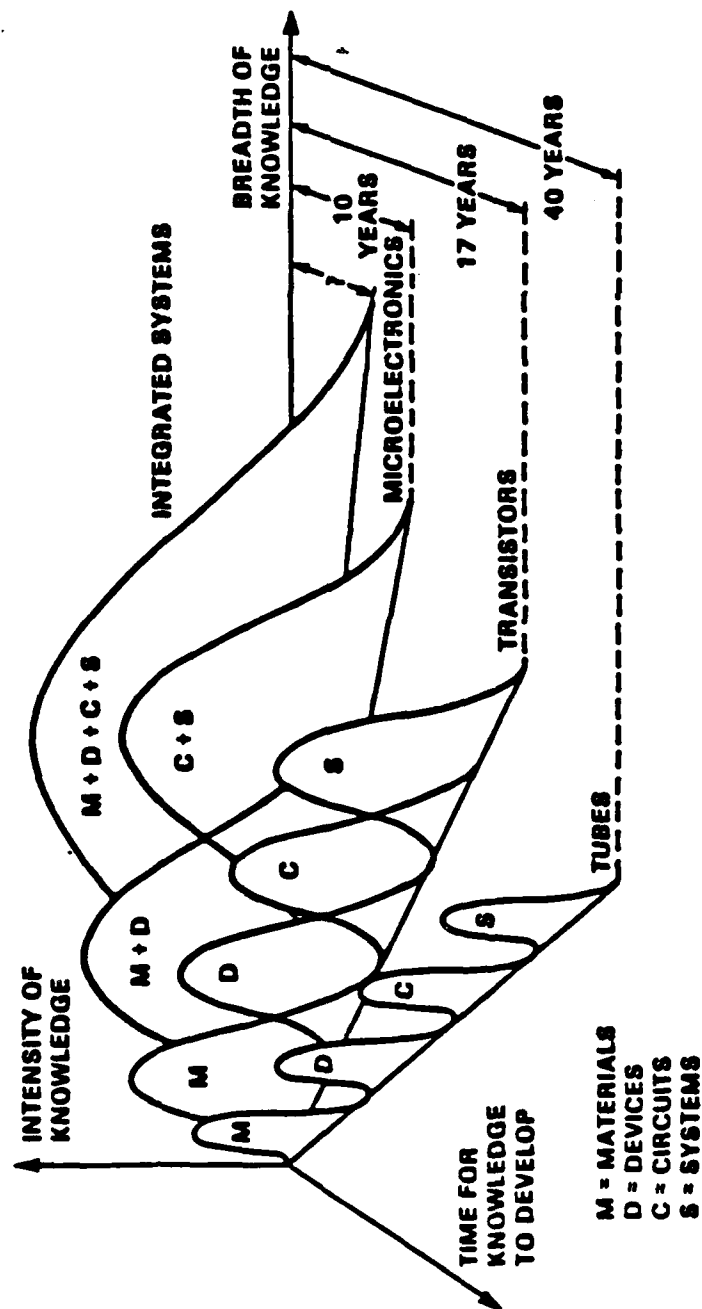COMMERCIAL - 250 WORDS/PAGE

MILITARY - 450 WORDS/PAGE

Figure 3. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
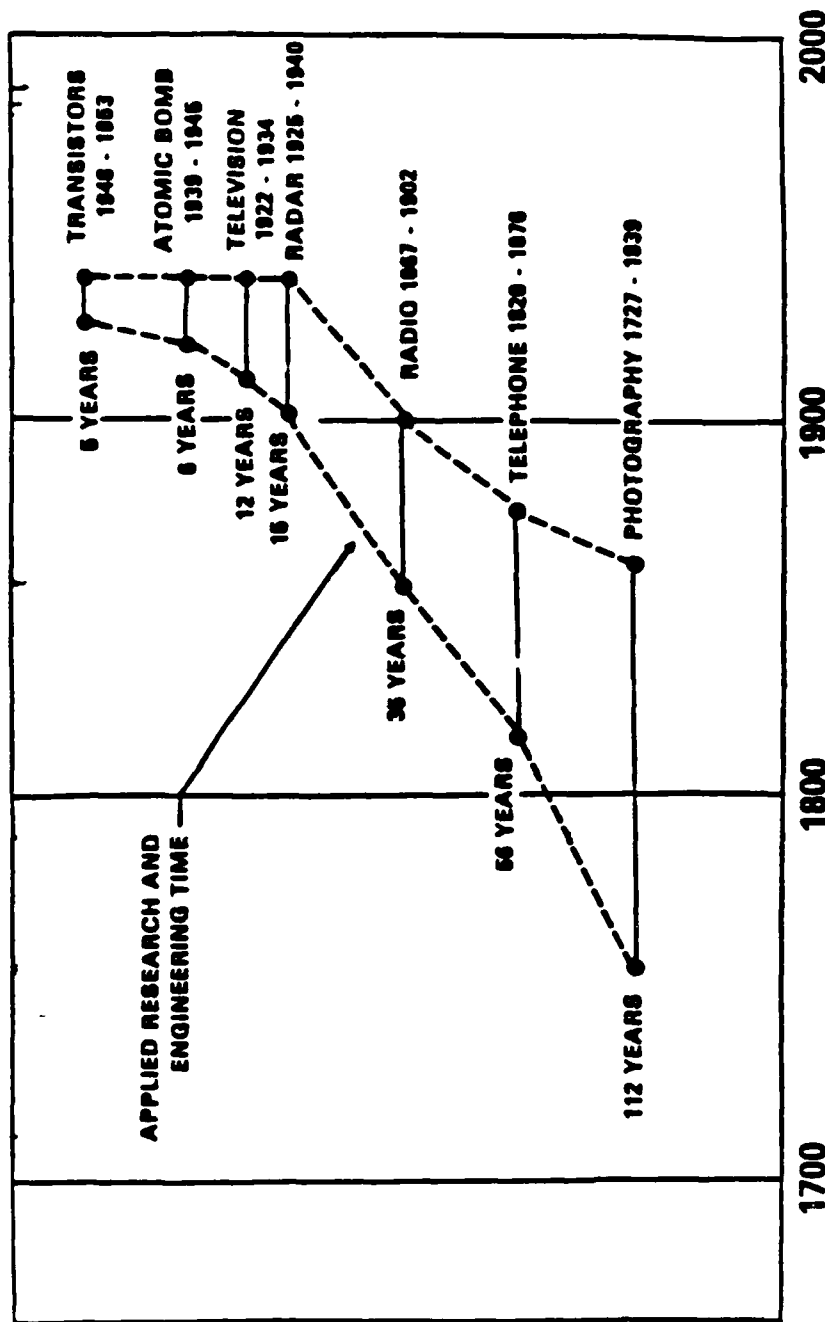
PROGRESS IN ELECTRONICS TECHNOLOGY

Figure 4. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 5. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
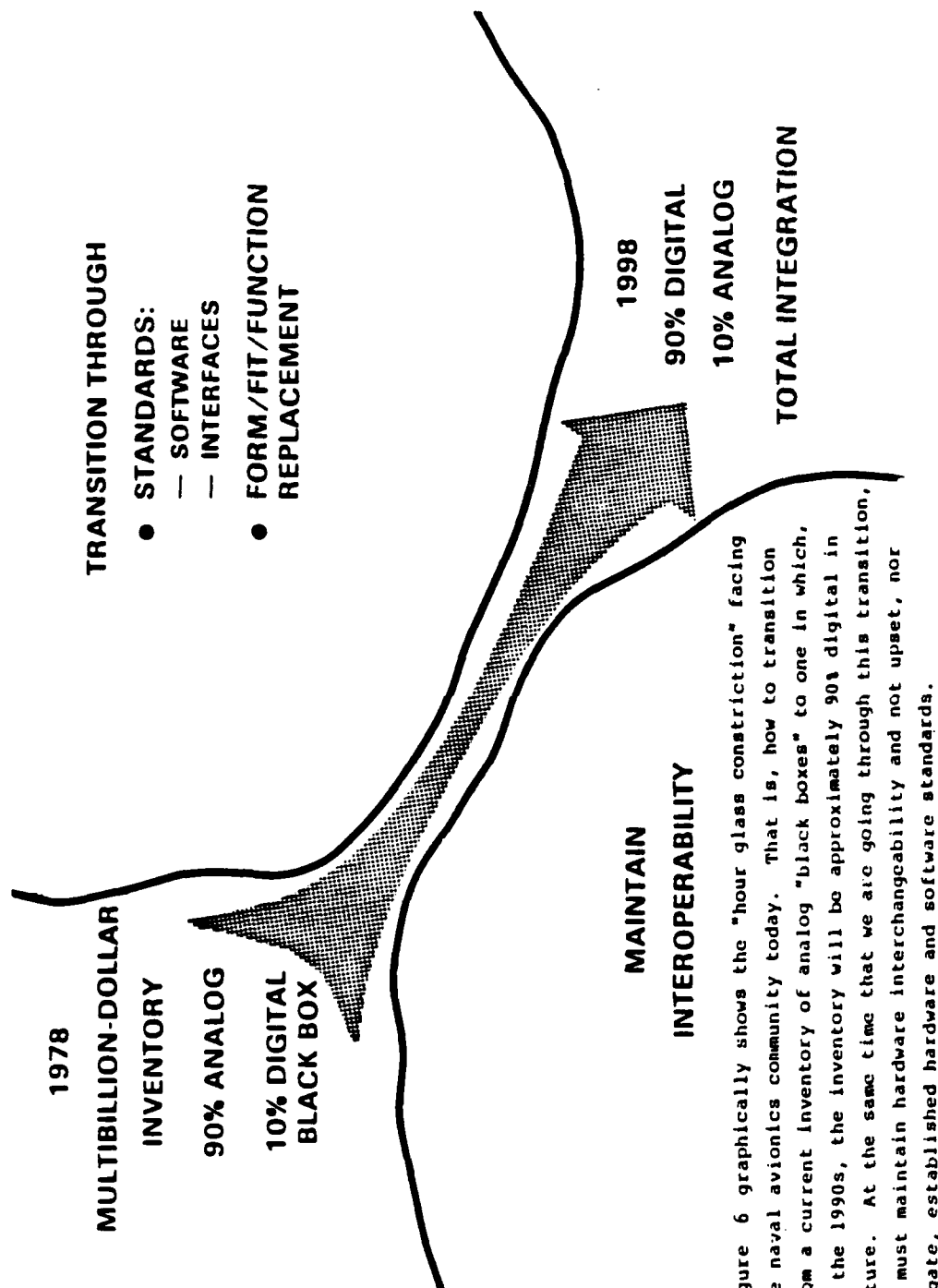
1978

MULTIBILLION-DOLLAR INVENTORY

90% ANALOG

10% DIGITAL BLACK BOX

TRANSITION THROUGH

- **STANDARDS:**
  - **SOFTWARE**
  - **INTERFACES**
- **FORM/FIT/FUNCTION REPLACEMENT**

1998

90% DIGITAL

10% ANALOG

TOTAL INTEGRATION

MAINTAIN

INTEROPERABILITY

Figure 6 graphically shows the "hour glass constriction" facing the naval avionics community today. That is, how to transition from a current inventory of analog "black boxes" to one in which, by the 1990s, the inventory will be approximately 90% digital in nature. At the same time that we are going through this transition, we must maintain hardware interchangeability and not upset, nor negate, established hardware and software standards.

Figure 6. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

NAVAL AVIATION USE OF MEMORY TECHNOLOGY

YEAR OF INTRODUCTION	TECHNOLOGY
MID-TO LATE 1960's	CORE/MAG, TAPE
1972	CORE/DRUM/TAPES
1974	MAG, FILM/DRUM/ TAPE/BIPOLAR
1974	CORE
	2X CORE
1985	CMOS SOLID-STATE DRUM
1987	BIPOLAR E^2PROM
1990	BIPOLAR/RAM E^2PROM

Figure 7. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
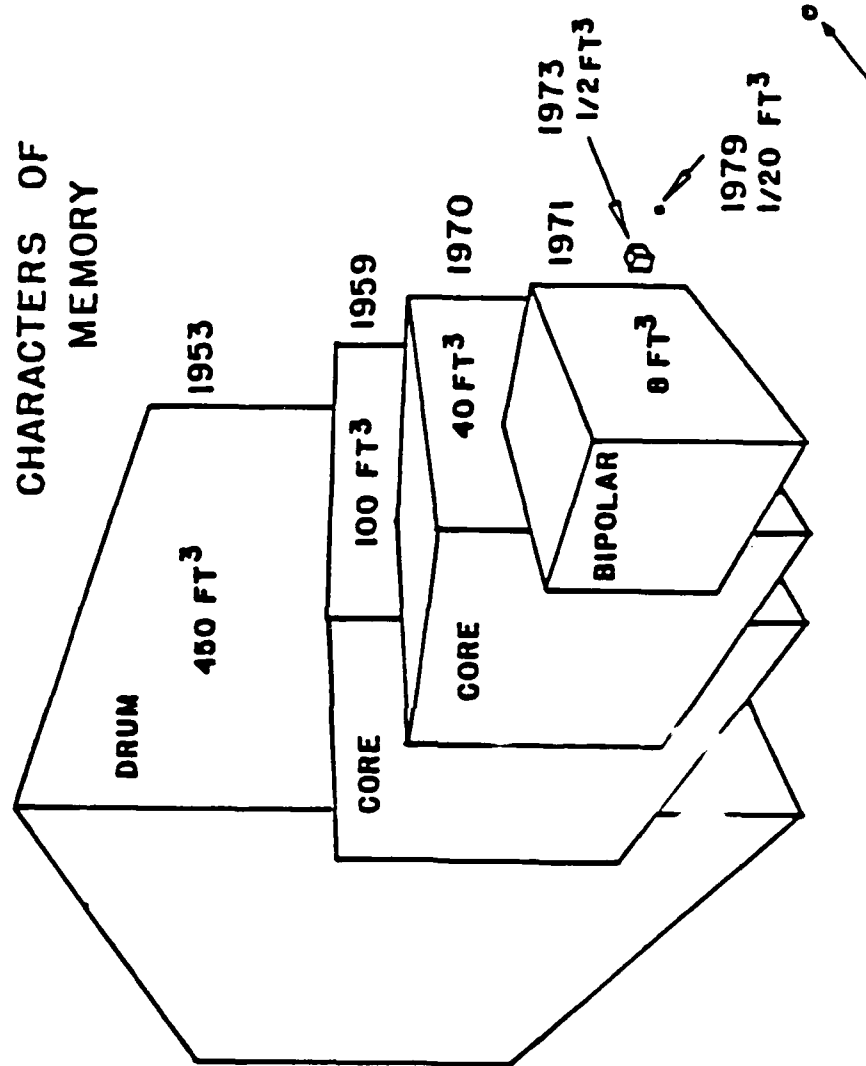
ONE MILLION
CHARACTERS OF
MEMORY

DRUM
450 FT^3
1953

CORE
100 FT^3
1959

CORE
40 FT^3
1970

BIPOLAR
8 FT^3
1971

1973
1/2 FT^3

1979
1/20 FT^3

1986
1/3 SIZE OF A U S DIME.

Figure 8. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
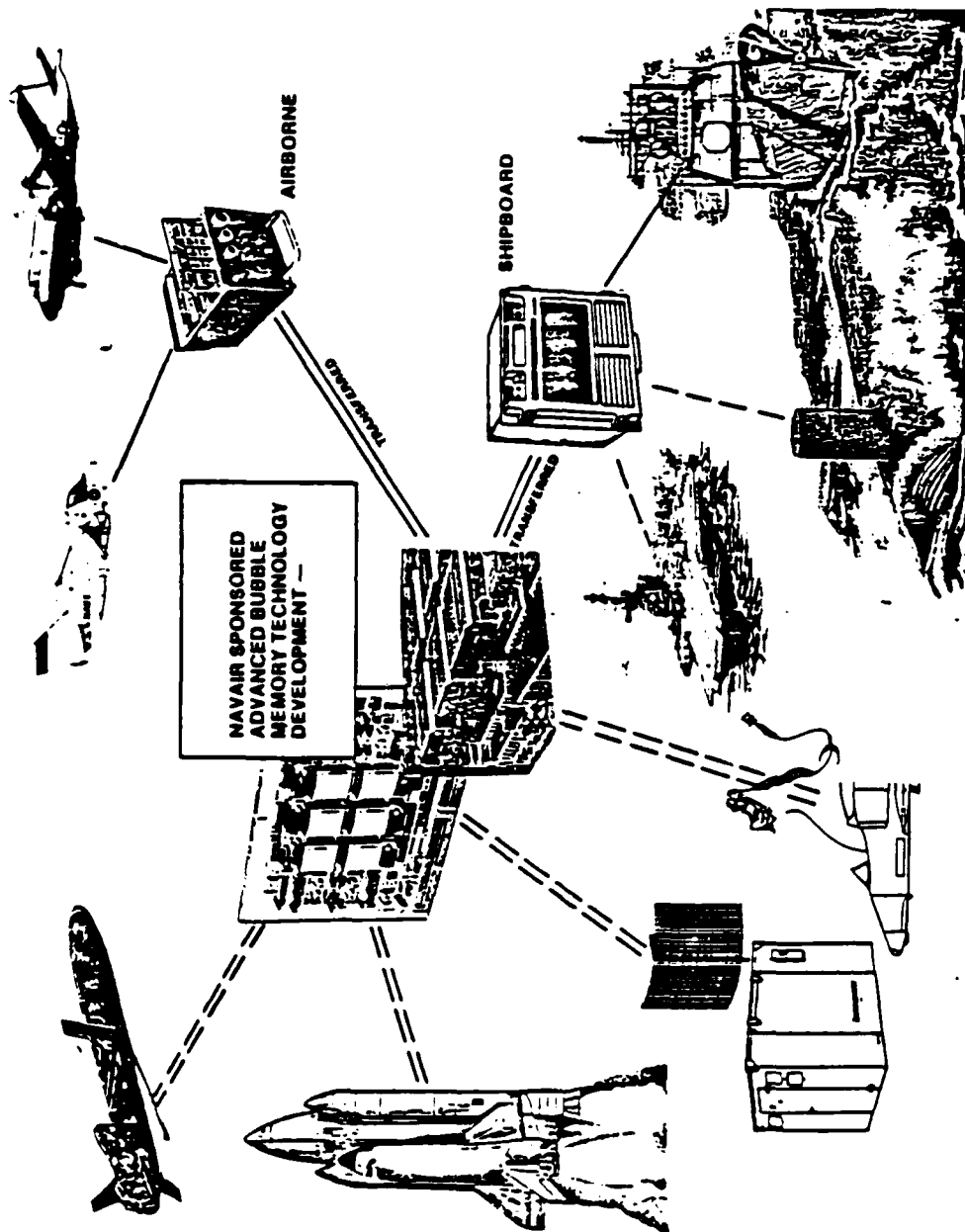
26/OMTR

TECHNOLOGY TRANSITION & INSERTION FLOW CHART
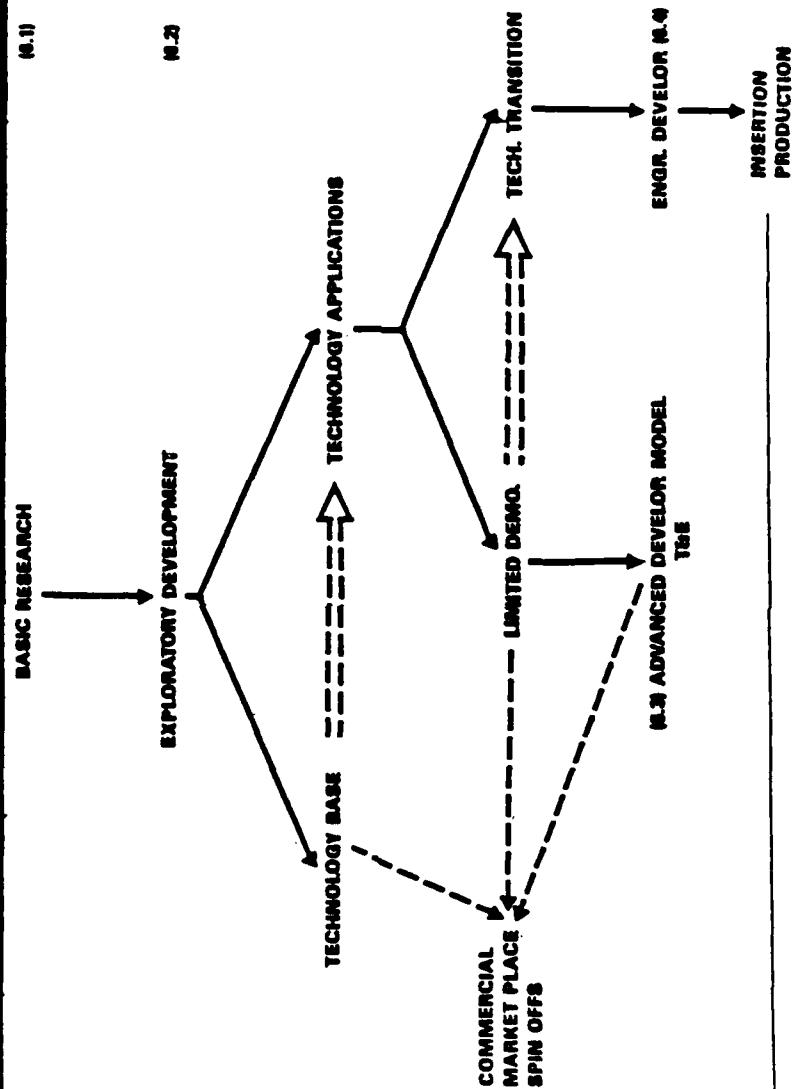
Figure 9. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPL, Washington, DC 20361-3500.
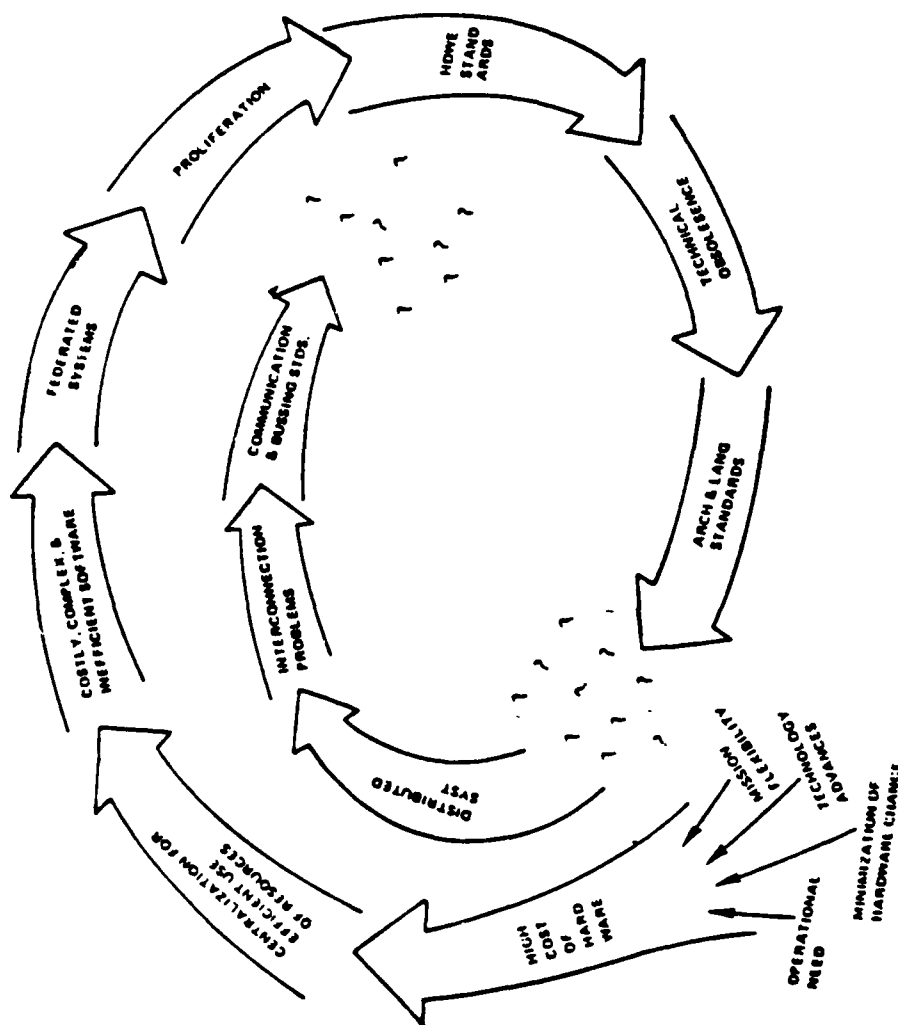
Figure 10. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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PATH THROUGH
TECHNOLOGICAL ADVANCEMENT

PATH THROUGH TECHNOLOGICAL ADVANCEMENT

(see Figure 11)

By the early 1960s, naval aviation operational needs in combination with the need for on-board equipment flexibility lead to the introduction of general purpose, programmable digital computers into naval aircraft/avionic systems. The programmability of the machines permitted rapid changes to be made through software modifications rather than through hardware changes. The advent of the integrated circuit also hastened the introduction of general-purpose digital computers throughout naval aviation because of the weight and volume savings that these devices have over other competing technologies. These "first generation airborne computers" were termed "centralized"; that is, all Operational Flight Programs (OFPs) are contained in a single machine. Unfortunately, while computer hardware made great strides forward in the state-of-the-art during this point in time, attendant software tools did not. Thus, while the use of digital computers in naval aircraft allowed the introduction of many new operational capabilities, navy management also had to live with costly, highly complex, and in many instances, inefficient use of the computer as an operational resource due to the (then) lack of quality software development tools.

As the solid-state technology matured and its products applied to militarized computers, the physical characteristics of the on-board computers decreased, which, in turn, led to the appearance of a number of light-weight, lower cost computers which, in turn themselves, led to their incorporation (physically) into the various subsystems themselves. Thus the term "embedded computers" came about. And eventually, these machines were connected together in what could be termed a "federation" of computer resources.

As time progressed, the introduction of general-purpose, programmable digital computers continued to bring about quantum improvements in operational capabilities to fleet aircraft. Unfortunately, due to the (then) lack of computer hardware standards, these machines were individually unique from both the hardware and software support standpoint. This situation was further exacerbated by the fact that the solid-state technology industry continued to introduce microelectronic circuits with greater densities, higher speed performance, and myriad circuit types which made obsolete almost over-night technology advancements which had not yet been fully operationally utilized in the fleet environment.

The continuation of proliferation of hardware, the absence of suitable standards, and the ever-increasing speed at which new solid-state devices were being invented and/or created and then manufactured, led to the establishment by the late 1970s of standards for computer hardware and the related higher order languages. As a generalization, it can be stated that this is the technical management situation which exists today throughout all of the three services.

As we enter the decade of the 1980s, there are many questions yet to be answered relative to computer architectural and language standards. Specifically, it is postulated that the decade of the 1980s and 1990s will see the introduction of Real-Time Computer-Controlled, Aircraft Distributed Systems containing several hundred microprocessors interconnected by various digital bus schemes. These microprocessors will be embedded throughout the aircraft as computer resources which control the operation of a highly fault-tolerant, reconfigurable, hierarchically structured aircraft/avionics system.
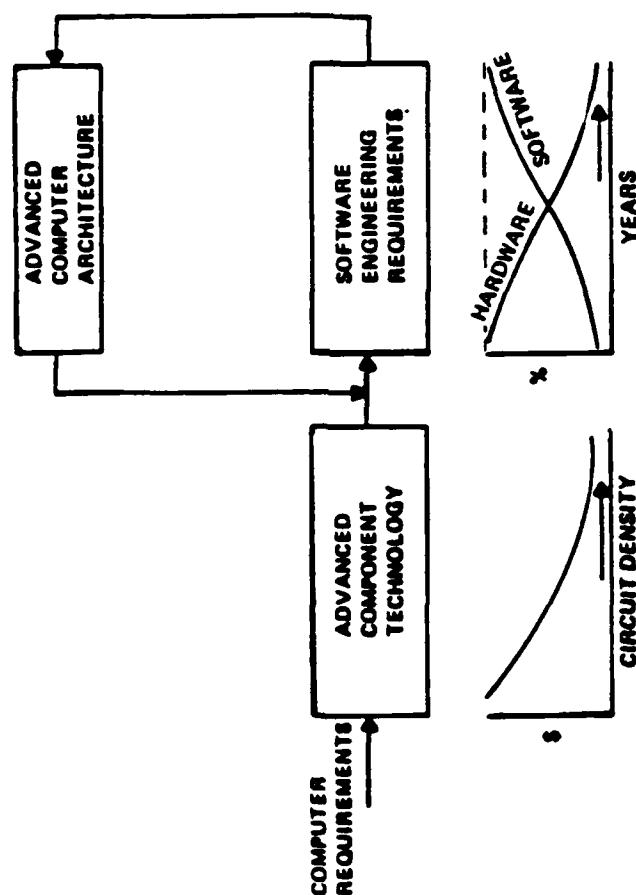

Figure 12. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 13. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

TECHNICAL APPROACH

(see Figure 13)

The technical approach to the development of aircraft/avionic digital computers over the past fifteen years or so is graphically shown in Figure 13. As stated previously, the introduction of solid-state digital (integrated circuits) devices permitted the rapid introduction of general-purpose computers into naval aircraft. As a function of time, the cost of these integrated circuits decreased dramatically, thus in turn, decreasing the total cost of the computer hardware. As illustrated, the attendant software costs rose almost as fast as were hardware costs decreasing. This economic reversal of costs gave rise to a whole new field of endeavor which was then covered by the broad generic title of "software engineering".

Encompassed under the aegis of the emerging software engineering discipline, one could find such tasks, activities, and efforts such as: analysis and design, test and evaluation, documentation, verification and validation, higher order languages and compilers. More recently, the term software engineering appears to have lost favor, and is being replaced by terms such as software environment, software tools, and software works (factory?).

Regardless of the names given to these various software-related efforts and their individual merit and/or quality, their impact upon reducing the cost of operational software costs was indeterminate at best because of the lack of standard hardware during that particular period of time. Specifically, with each new computer introduced into the fleet inventory, the software support was unique unto itself and thus added to the already heavy logistic burden. However, it was not until the technical managers came to the full realization that in order to reduce software costs, a standard computer architecture had to be identified. Specifically, an Instruction Set Architecture (ISA) had to be identified and selected as a standard if we were to gain any control over the sky-rocketing costs for generating and supporting naval aircraft Operational Flight Programs.

Figure 14. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPI, Washington, DC 20361-3500.

REASONS FOR PROLIFERATION
OF HARDWARE

EQUIPMENT PROCURED AT DIFFERENT PERIODS IN TIME

DIFFERENT PROCUREMENT METHODS

PROCUREMENT BY DIFFERENT ACTIVITIES

USE IN DIFFERENT VEHICLES

URGENCY TO MEET DEPLOYMENT REQUIREMENTS

LACK OF STANDARD EQUIPMENT

Figure 15. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

REASONS FOR PROLIFERATION OF HARDWARE:

(see Figure 15)

Figure 15 lists the major reasons for proliferation of naval aircraft/avionics programmable digital computers over the past decade or so. The reasons given are considered to be self-explanatory. Perhaps in the future, one or more of these reasons may again be used to introduce yet another new computer. On the other hand, the last reason listed in the figure - "Lack of Standard Equipment" - is no longer valid nor acceptable for introducing a new machine without compelling major management or operational considerations. For as is well known to those individuals associated with R&D efforts sponsored by the Naval Air Systems Command, there is currently an established aircraft/avionic standard modular digital computer - the AN/AYK-14.

Figure 16. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

REPRESENTATIVE SOFTWARE SYSTEMS

Figure 17. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

REPRESENTATIVE SOFTWARE SYSTEMS

(see Figure 17)

Figure 17 provides a rather dramatic graphical overview of the myriad types of software systems which must currently be supported by NAVAIR management. Additionally, only when one considers the fact that the majority of these software "packages" are either updated, modified, or changed over a period of time for a multitude of reasons can the true dimension of the enormity of software management, control, and maintenance be fully appreciated.
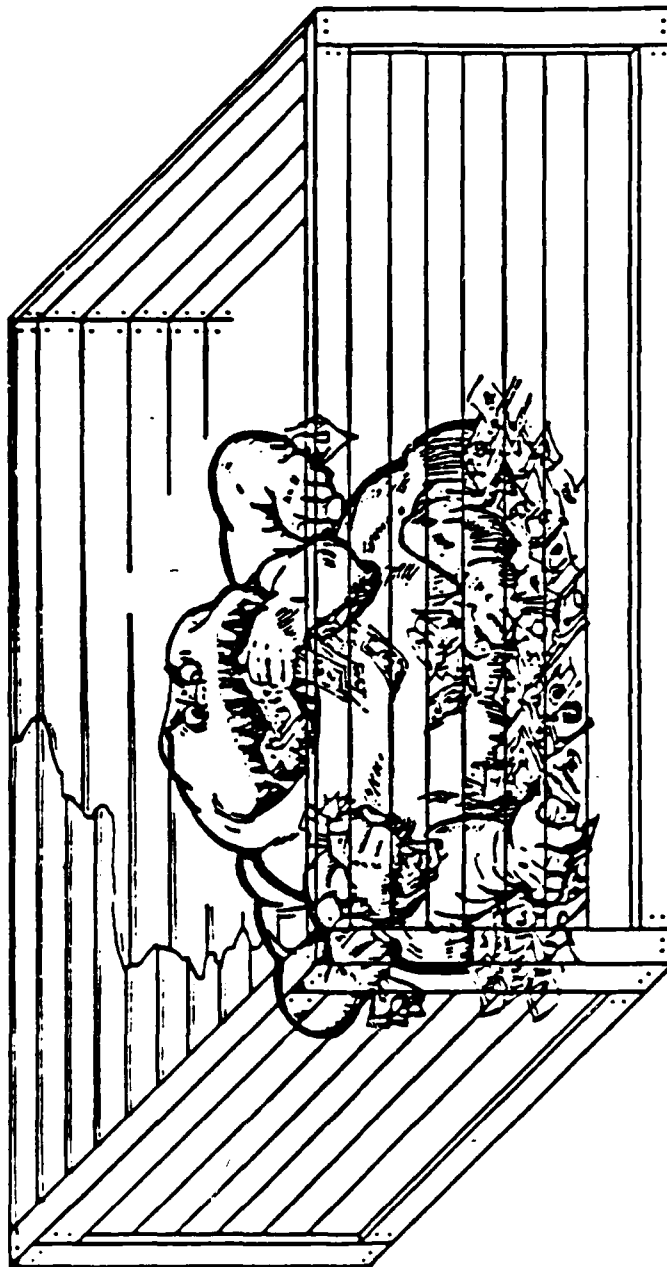

Figure 18. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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the

Software Monster

Figure 19. "Optical Memory Storage Requirements and Applications for Use in Military Environments." Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPI, Washington, DC 20361-3500.

the

Software Monster

Figure 20. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(see Figure 20)

Along with the explosion of applications of programmable computers came an unwanted "Software Monster" whose ferocious appetite for consuming great mouthfulls of dollars (color him green) seemed unlimited. Proliferation of hardware, coupled with the fact that software development, test and evaluation, and support depends very heavily upon a highly manpower-intensive market has helped to feed the Software Monster on a continuuius basis ever since the initial introduction of programmable machines into naval aircraft systems.

Figure 21. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

1940 - 60 ANALOG	1960 - 80 CENTRAL DIGITAL	1980 - 2000 DISTRIBUTED DIGITAL
• WIRED PROGRAMS	• STORED PROGRAM	• DISTRIBUTED HIERARCHIAL STORED PROGRAM
• DEDICATED ANALOG PROCESSORS	• CENTRAL PROCESSOR(S)	• REDUNDANT CENTRAL PROCESSOR(S)
• INTEGRATION THROUGH	• COMMUNICATION THRU I/O INTEGRATION THROUGH CENTRAL PROCESSOR/STORED PROGRAM	• DISTRIBUTED DEDICATED FUNCTIONAL PROCESSORS
• NO REDUNDANCY	• SOME REDUNDANCY	• COMMUNICATION THRU BUS NETWORK
• LITTLE FAULT TOLERANCE	• SOME FAULT TOLERANCE	• LARGE SCALE USE OF REDUNDANCY
• NO DYNAMIC RECONFIGURATION CAPABILITY	• NO DYNAMIC RECONFIGURATION CAPABILITY	• FAULT TOLERANCE AND DYNAMIC RECONFIGURATION
• DISCRETE & SSI HARDWARE	• MSI & LSI HARDWARE	• HARDWARE

Figure 22 lists, by decades, the technical characteristics of aircraft/avionic equipments. It is self-evident, of course, that for the time period 1980 - 2000, the items listed have yet to be fully implemented.

Figure 22. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
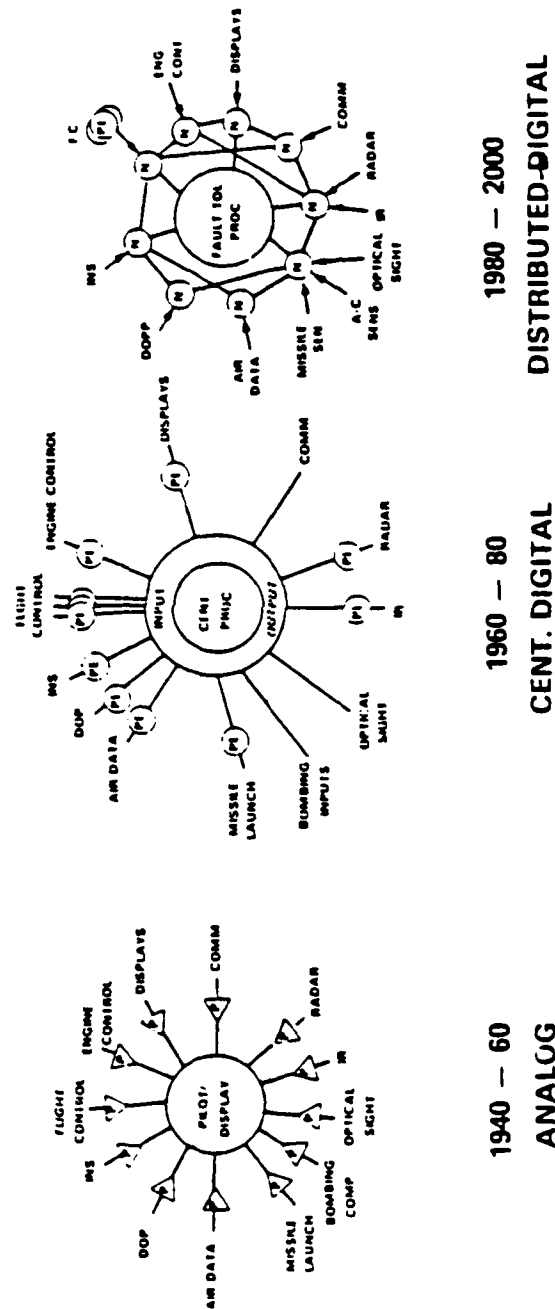
AVIONICS SYSTEM ARCHITECTURES

Figure 23. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

1940 — 60
ANALOG

1960 — 80
CENT. DIGITAL

1980 — 2000
DISTRIBUTED DIGITAL

Figure 23 depicts in topography form, the classical Analog, Centralized Digital, and postulated Distributed Systems implementations for the designated time frames.

OTMR/41

AVAILABILITY

- BITE

- REDUNDANCY

- RECONFIGURABILITY

- MAINTAINABILITY

Figure 24. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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AVAILABILITY

(see Figure 24)

In order for any future naval aircraft to be fully operationally "available" from the standpoint of the on-board avionics, it must have incorporated into the basic system architecture the characteristics itemized in Figure 24. In order to achieve a high level of system availability, Built-In Test Equipment (BITE), must be complemented be redundancy schemes and reconfigurability of subsystem functions and capabilities. Maintainability of avionics systems in an austere environment has also become a mandatory operational requirement.

Figure 25. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

SYSTEM

PSEUDO-HIERARCHIAL
ARCHITECTURAL STRUCTURING

- TOTAL AIRCRAFT/AVIONICS SYSTEM

- PARTIONING OF AIRCRAFT/AVIONICS SUB-SYSTEMS

- INTER-CONNECT BUS STRUCTURE

- SYSTEM-WIDE PROCESSING ARCHITECTURE

- SUB-SYSTEMS DEFINITION

- COMPUTER SYSTEMS

Figure 26. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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SYSTEM PSEUDO-HIERARCHICAL ARCHITECTURAL STRUCTURES

(see Figure 26)

As we enter the decades of the 1980s, there is an absence of a generally accepted system architectural approach to the design and development of on-board aircraft/avionics equipments and systems. In the absence of any systems architectural definition, I have proposed, as shown in Figure 26, a "Pseudo-Hierarchical Architectural structuring". I have chosen to designate this concept as "pseudo" solely because of the current lack of a "reduction to practice" of such an approach. It should be noted, however, that the top-down decomposition of the system architectural structure is real from an engineering design viewpoint and does indeed lend itself to a logical, natural methodology for decomposition into its constituent parts.

Figure 27. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPL, Washington, DC 20361-3500.
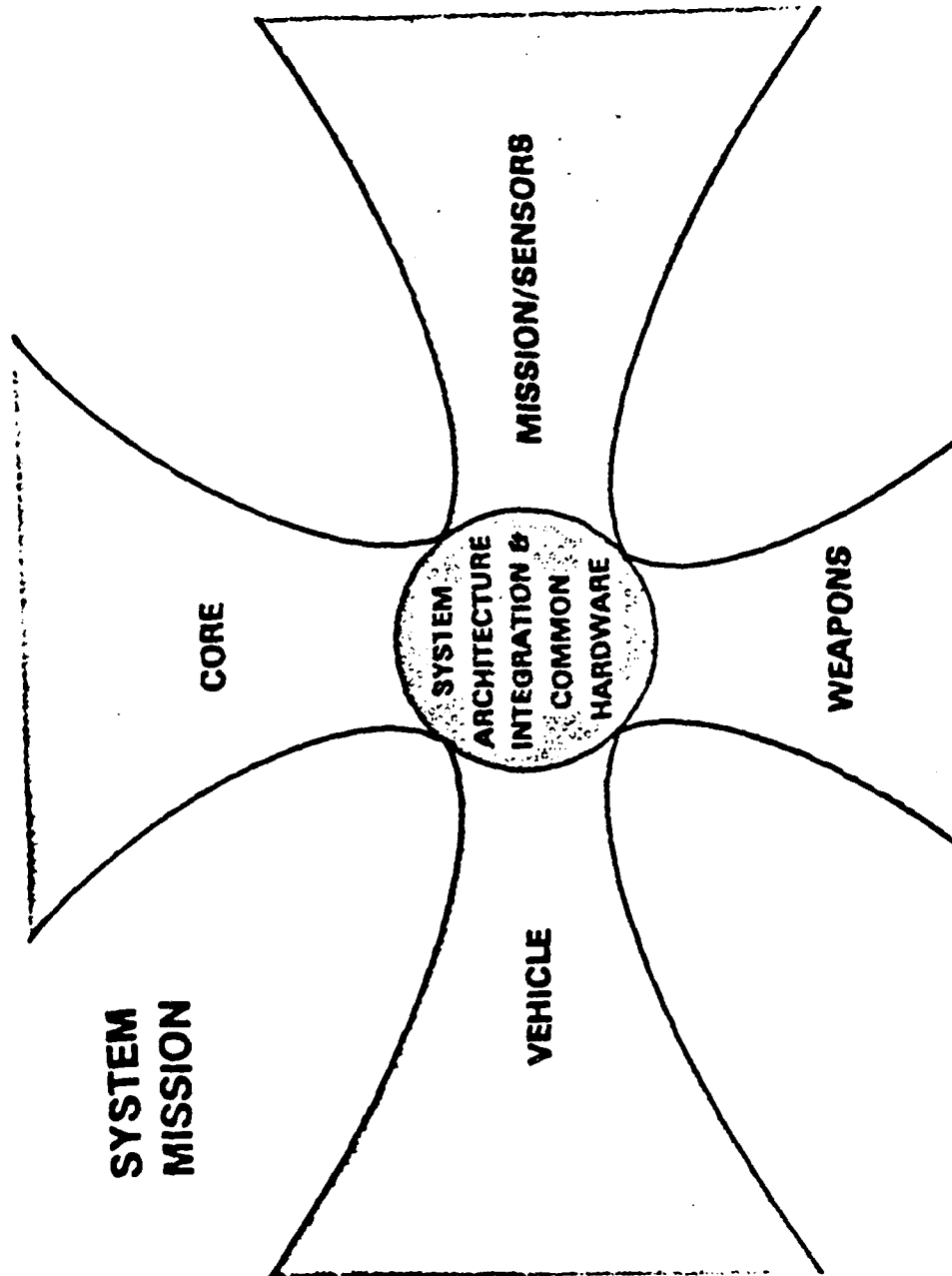
Figure 28. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

SYSTEM MISSION

CORE

MISSION/SENSORS

SYSTEM ARCHITECTURE INTEGRATION & COMMON HARDWARE

WEAPONS

VEHICLE

SYSTEM MISSION

(see Figures 26,28, and 30)

Assuming that the System Architectural Structuring concept is valid, one could state then that the "System Mission" of Figure 28 is the equivalent of the "Total Aircraft/Avionic System" listed previously in Figure 26. More specifically, each term represents the TOP of the system architectural structure shown in the viewgraphs.

Figure 28 illustrates how an aircraft designed for a given System Mission can be partitioned into a number of "clumps" of aircraft/avionic sub-systems. For example, the Vehicle clump of sub-systems would contain such equipments as the flight controls, pilots' displays, and the electrical generators. The Core clump would contain the communications, navigation, and the computational resources. The Mission/Sensors clump would contain the specific radars, acoustic sensors, or the electronic warfare equipments. The Weapons clump is of course self explanatory as to its contents.

It should be noted that these four major portions or clumps of sub-systems are "glued" together by the System Architecture, Integration, and Common Hardware as shown in the center circle in Figure 30.

Figure 29. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
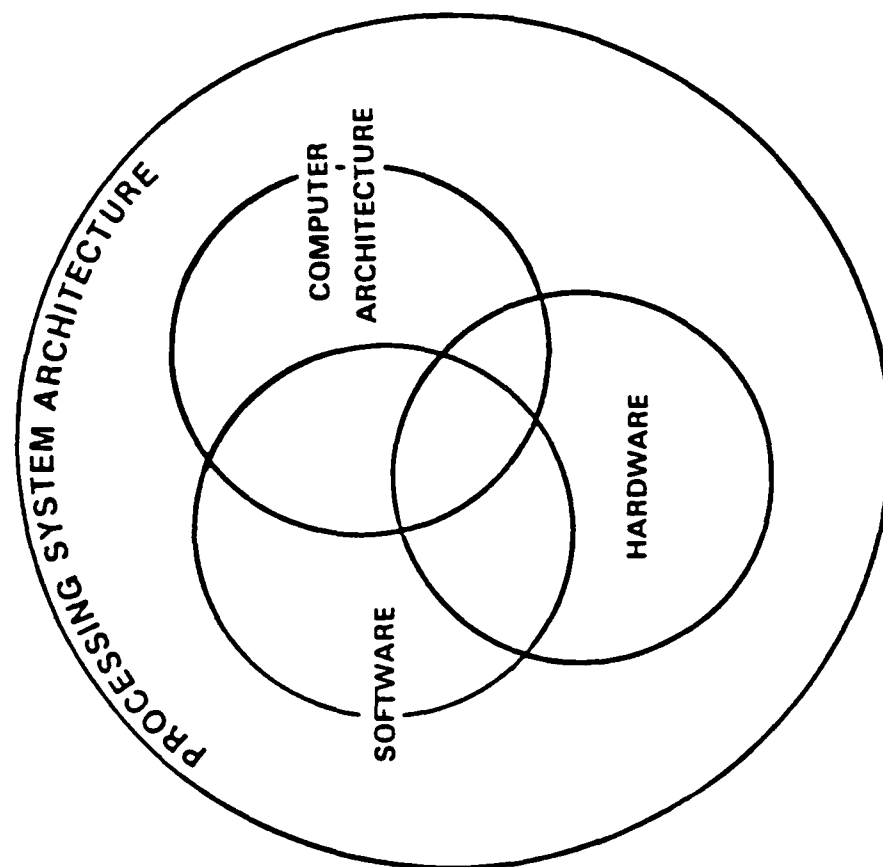
Figure 30. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20301-3500.

PROCESSING SYSTEM ARCHITECTURE

(see Figure 30)

Figure 30 depicts what I have chosen to call "Processing System Architecture" (PSA). The PSA consists of the software, hardware, and computer architecture, interconnected as shown so as to indicate the inseparability of the three prime facets of the on-board embedded computer resources.
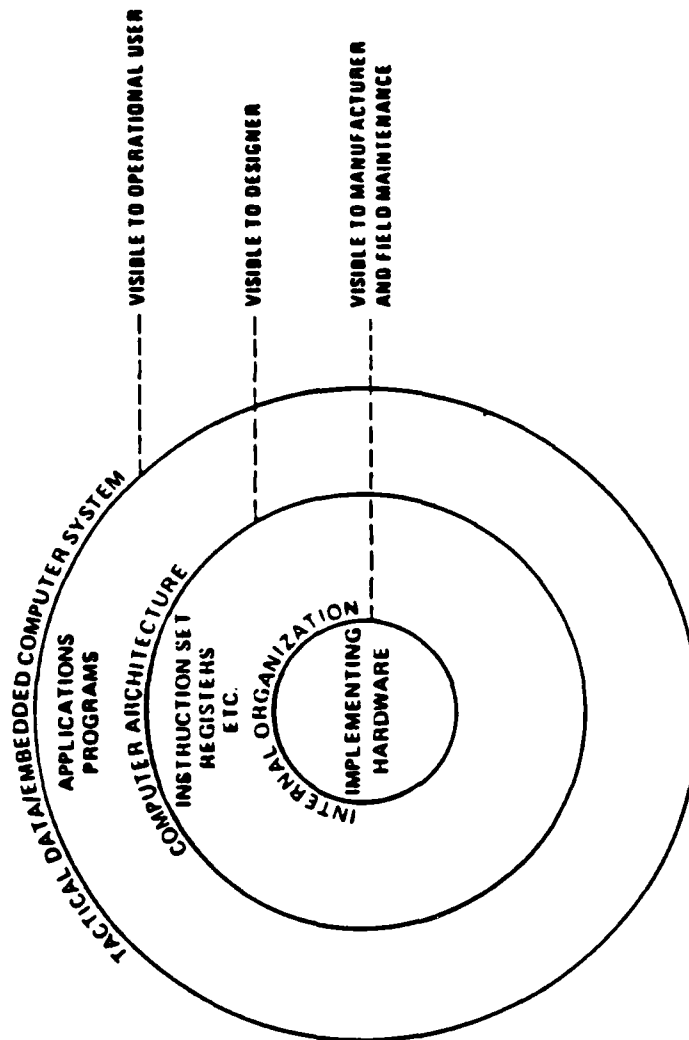
Figure 31. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

ARCHITECTURE DEFINED

ARCHITECTURE IS USED HERE TO DE
SCRIBE THESE ATTRIBUTES OF A COM
PUTER VISIBLE TO THE PROGRAMMER
AND DOES NOT INCLUDE IMPLEMEN
TATION DETAILS

TACTICAL DATA/EMBEDDED COMPUTER SYSTEM

APPLICATIONS
PROGRAMS

COMPUTER ARCHITECTURE

INSTRUCTION SET
REGISTERS
ETC.

INTERNAL ORGANIZATION

IMPLEMENTING
HARDWARE

VISIBLE TO OPERATIONAL USER

VISIBLE TO DESIGNER

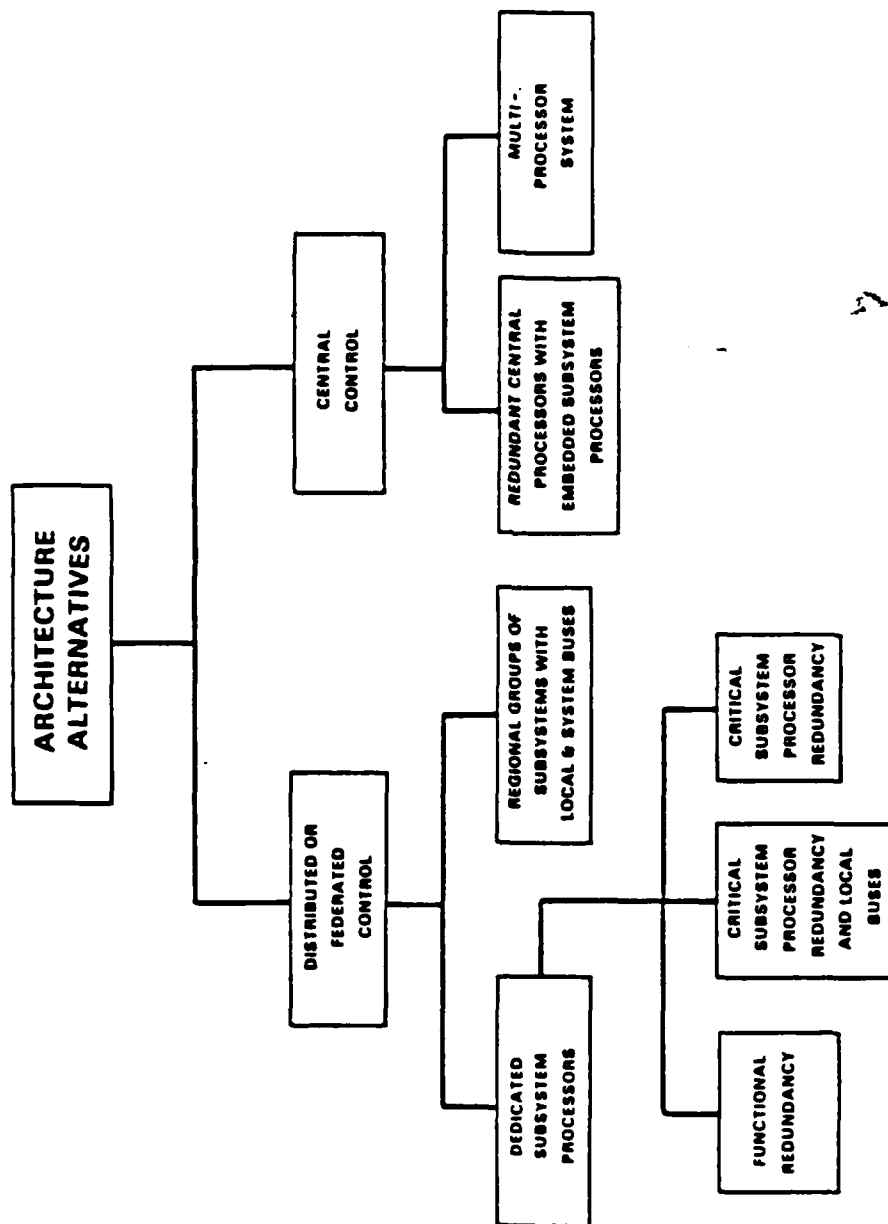VISIBLE TO MANUFACTURER
AND FIELD MAINTENANCE

Figure 32. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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ARCHITECTURE DEFINED
(see Figure 32)

The prose provided with the graphical representation of the various aspects of the on-board embedded computer resources as seen by the various users more than adequately defines the term "Architecture". For information purposes, Figure 32 was used as part of the material which was given to a number of audiences to which the concept of the Military Computer Family (MCF) Program was presented.

Figure 33. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 34. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

SYSTEM ARCHITECTURE ALTERNATIVES

(see Figure 34)

Figure 34 is a "road map" of the various System Architecture Alternatives available to designers and developers of future aircraft. It would seem reasonable to assume that more and more we will see the Distributed or Federated Control approaches used in future aircraft, while the Central Control approaches would be more likely to continue to appear in aircraft updates.

Figure 35. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

OMTR/53
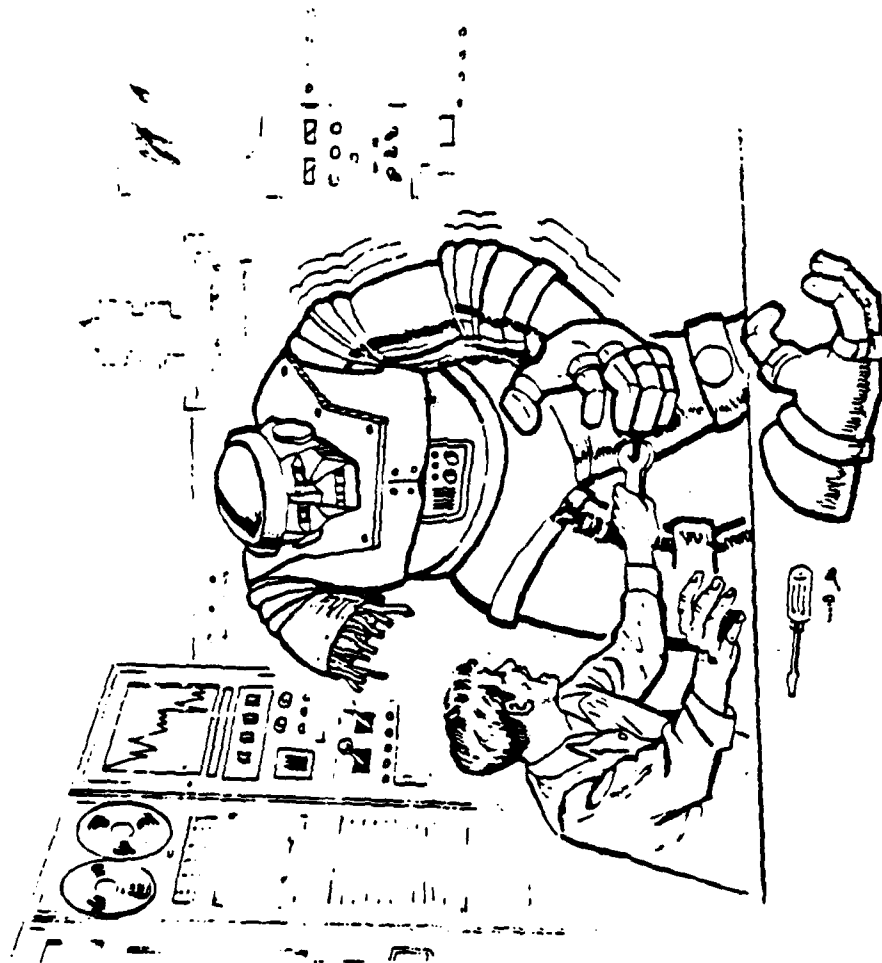
Figure 36. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(See FIGURE 36)

So far we have addressed many different concepts and approaches relative to the design of future aircraft/avionic systems. However, if we indescriminately exercise these various concepts, alternatives, and approaches, we could be creating a "Hardware Monster" not unlike the previously mentioned Software Monster.

For like the creator of the Frankenstein monster, the designer has to be certain of his control of the overall system architecture before putting the various parts together. Certainly it is not too far fetched to visualize a Hardware Monster "pasted" together from Government Furnished Equipment (GFE) and/or Contractor Furnished Equipment (CFE), and standard and/or non-standard parts, devices, and components, all of which are controlled by an electronic "heart" consisting of up to 200 microprocessors. This electronic heart would send out its digital "heart beats" over a "nervous system" made up of either a standard twisted-pair bus structure or a high-speed fiber optic bus structure. Needless to say, early in the system conceptual and definition phase of the program, the various options must be cut down at the earliest possible time.
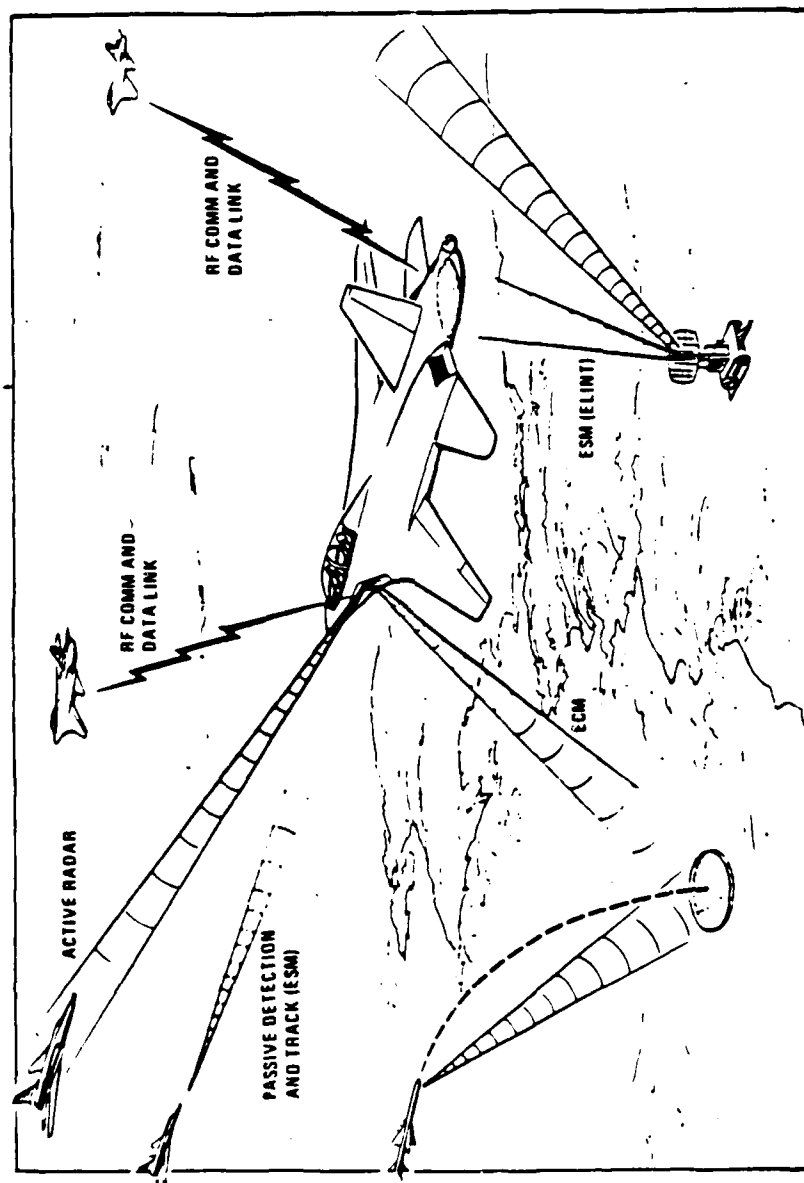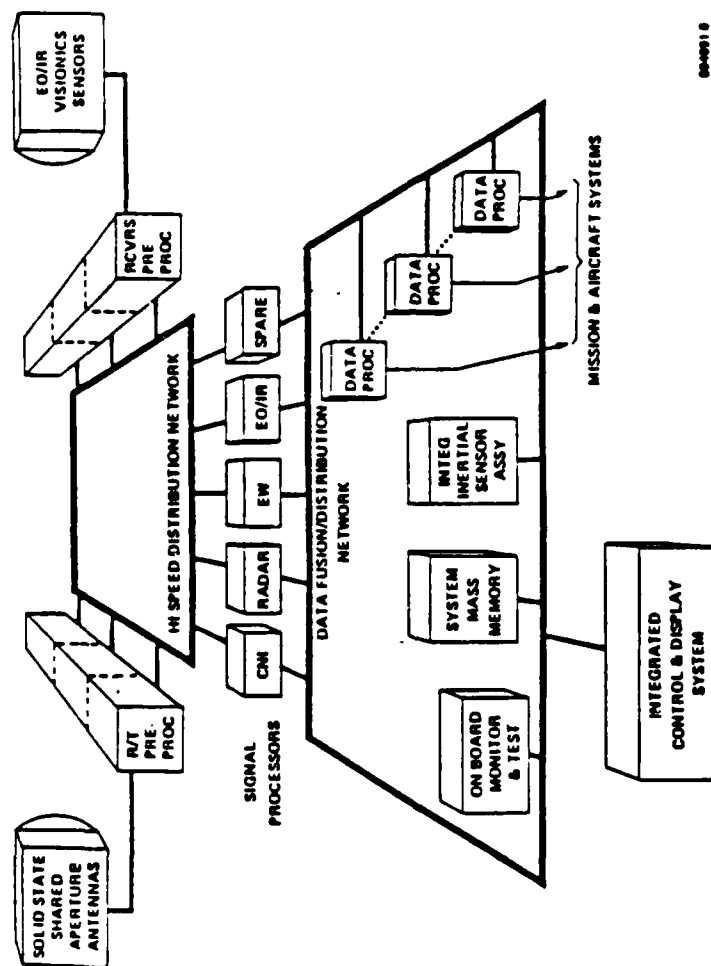
Figure 37. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

INTEGRATED MULTIFUNCTION APERTURE CONCEPT

● FUNCTIONS DETERMINED BY SOFTWARE   ● ALL ASPECT COVERAGE

ACTIVE RADAR

PASSIVE DETECTION AND TRACK (ESM)

RF COMM AND DATA LINK

RF COMM AND DATA LINK

ECM

ESM (ELINT)

Figure 38. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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AN INTEGRATED AVIONICS ARCHITECTURE EXAMPLE

Figure 39. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

SYSTEM DESIGN FEATURES - HARDWARE UTILIZATION

CHARACTERISTICS

IMPLICATION

STANDARDIZED INTERFACES — MULTISOURCE SUPPLY, TECHNOLOGY UPDATING SIMPLE

MULTIFUNCTION SENSOR ROLES — MAXIMUM FAULT/DAMAGE TOLERANCE

RECONFIGURABLE PROCESSING ELEMENTS — GREATER FAULT/DAMAGE TOLERANCE EASES LOGISTICS/MAINTENANCE

SERIAL DATA TRANSMISSION — LIGHTER, FEWER COMPONENTS

INTEGRATED, COORDINATED SYSTEM DESIGN — MAXIMUM FAULT/DAMAGE TOLERANCE PERFORMACE/\$ ADVANTAGE

Figure 40. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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PRIOR DIGITAL SYSTEMS

- INDEPENDENT SUBSYSTEM ORGANIZATION
- LIMITED CROSS UTILIZATION OF INFORMATION
- CENTRALIZATION OF COMPUTATION

FUTURE DIGITAL SYSTEMS

- RESOURCE SHARING ACROSS SUBSYSTEMS
- INFORMATION CORRELATION
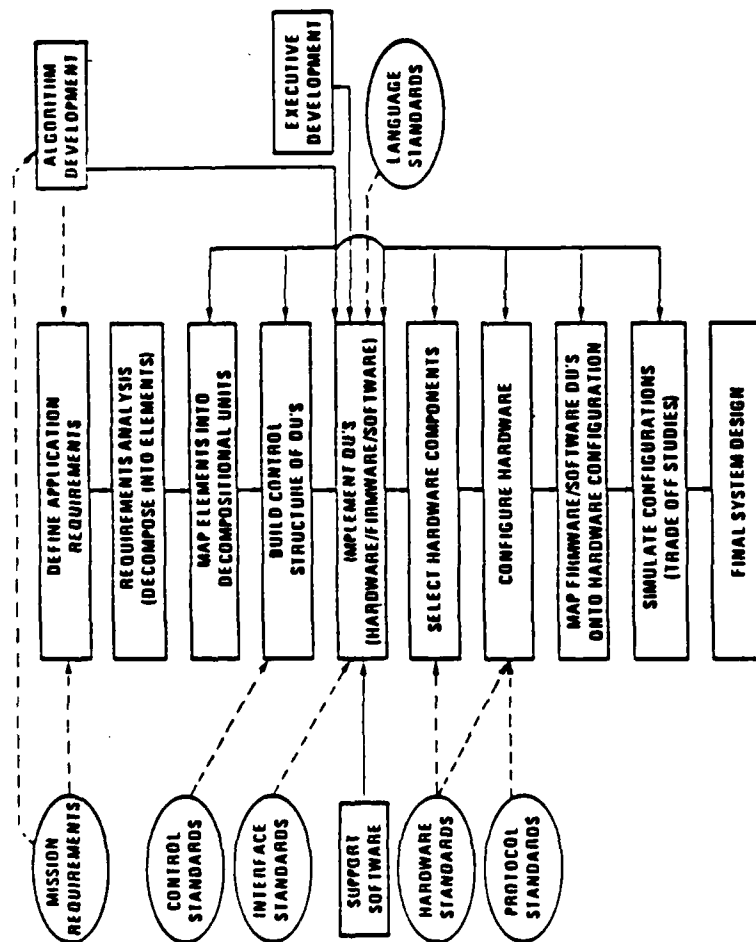- DECENTRALIZED COMPUTATION

— BUT CONTROL IS CENTRALIZED —

Figure 41. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

OMTR/59

RECONFIGURABLE SYSTEMS

HARDWARE IS EASIER

SOFTWARE IS TOUGHER

BUT--

ONCE SOLVED, SOFTWARE

- DOESN'T AGE

- IS TRANSFERABLE

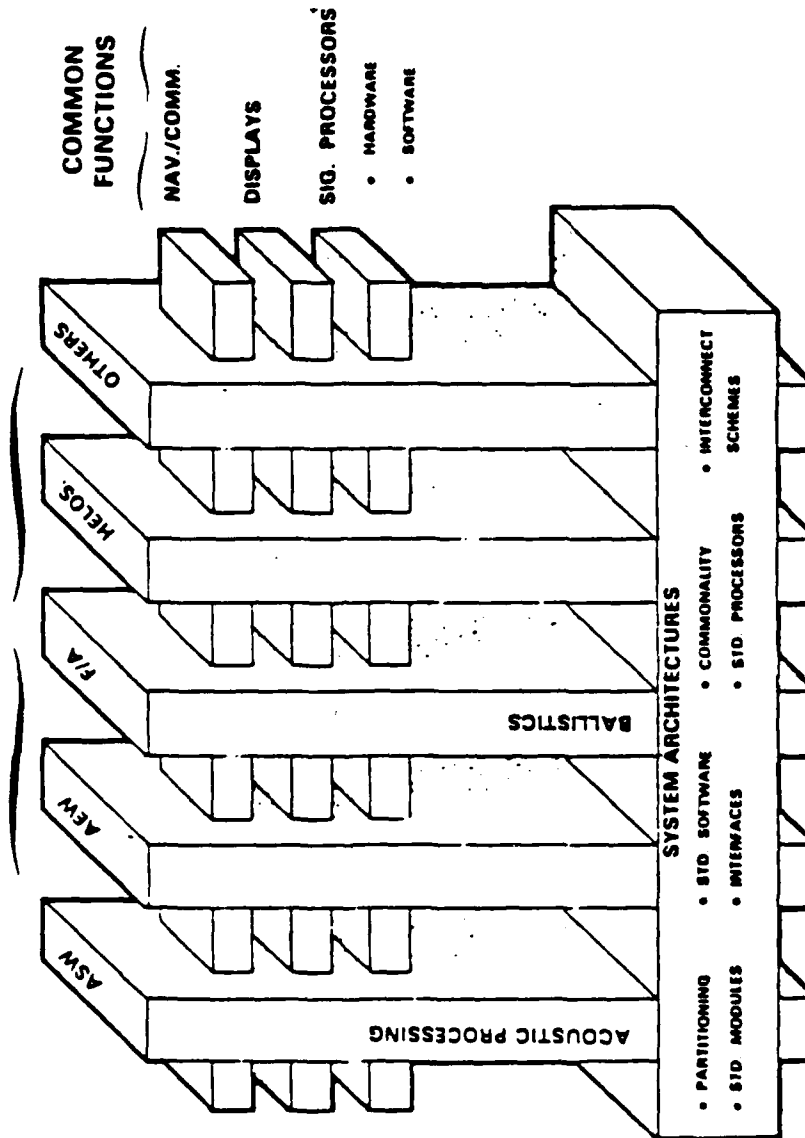- IS INDEPENDENT OF PRODUCTION VOLUME

BUT--

Figure 42. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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STRUCTURED DESIGN
A PREFERRED APPROACH

Figure 43. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

OMTR/61

STANDARDIZATION - ARCHITECTURE INTERACTION MATRIX

Figure 44. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

STANDARDIZATION - ARCHITECTURE INTERACTION MATRIX

(see Figure 44)

It is a sufficient enough problem for engineering managers to have to address the consequences of either the aforementioned Software Monster or the Hardware Monster independently. Unfortunately, future Real-Time, Computer-Controlled Distributed Systems require that both of these two "bugaboos" be addressed simultaneously, and with the same degree of management and technical attention.

Figure 44 is an attempt on my part to visually demonstrate the inter-relationships between computer software and hardware resources and the system architecture, integration, and common hardware requirements. It is hoped that the need for simultaneous consideration of all of these factors can be seen from the structure of the matrix.

In Figure 44, the foundation for the entire system is shown at the bottom of the viewgraph entitled "System Architecture". Being that it is a FOUNDATION, it cuts across each of the vertical bars which are meant to convey the idea that the "Missions" are independent, separable, and unique to each operational mission need. Contained within this concept of the System Architecture as the foundation upon which all the operational systems are built is the premise that any item identified within the block has general applicability to all naval aircraft systems (when required).

The horizontal bars listed under "Common Functions" are used to indicate equipments or software which cut across various Missions, but are uniquely tailored to the particular operational application. For example, signal processors and their associated software programs are used in many naval aircraft; however, it is only for the Anti-Submarine Warfare (ASW) Mission that the processor and its associated software are tailored for the acoustic processing role. In like fashion, the aircraft displays may have some identical hardware and software used across all aircraft, but again, any one particular combination of controls and displays is unique to each Mission application.

Figure 45. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

The ideal answer to concerns over the proliferation of both hardware and software is shown in Figure 46. Here we have a single production line manned by anthropomorphic microelectronic circuit boards producing a single standard microcomputer.
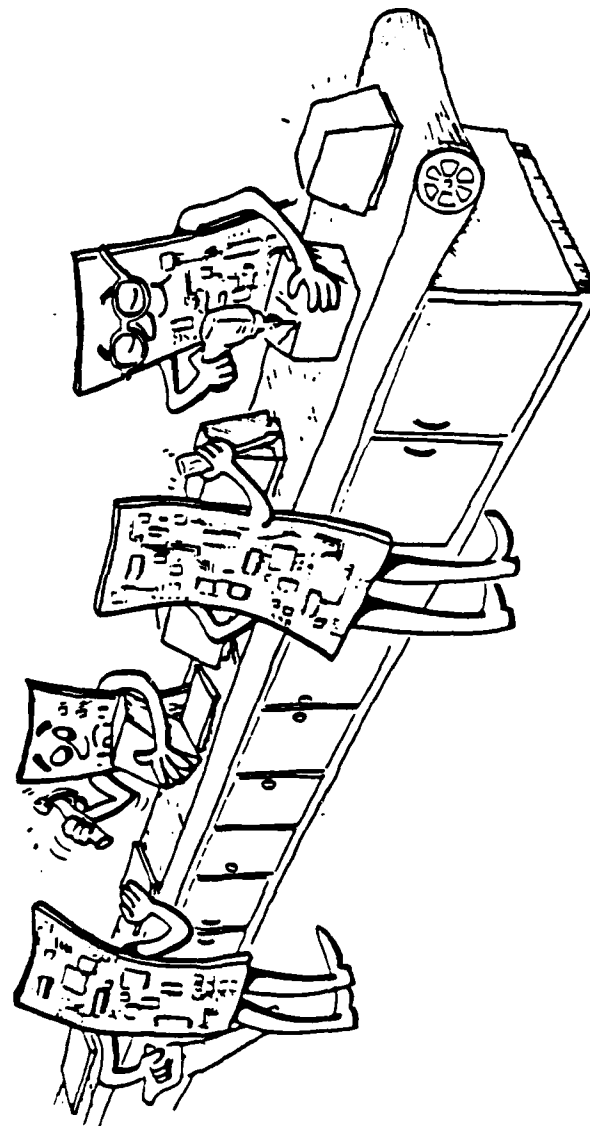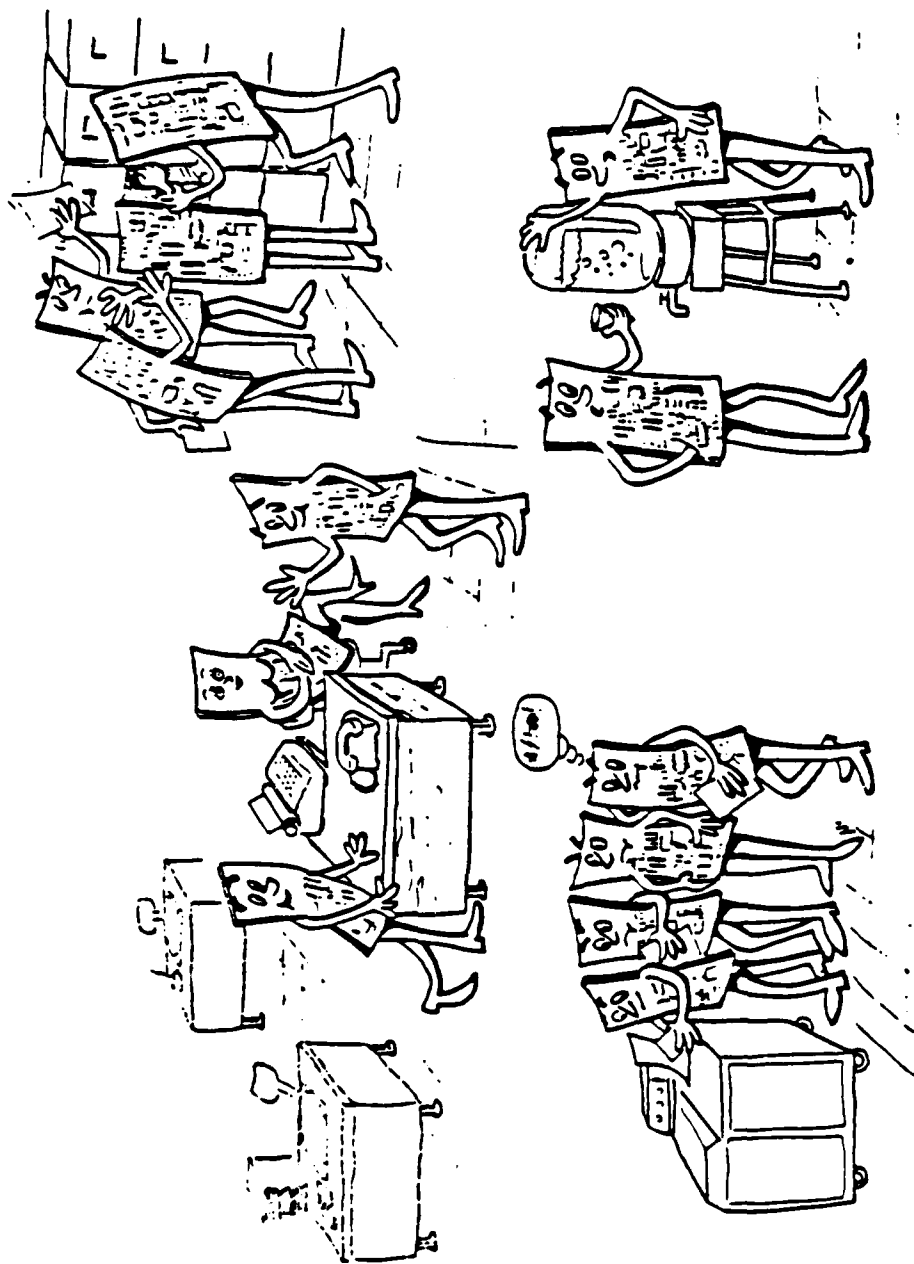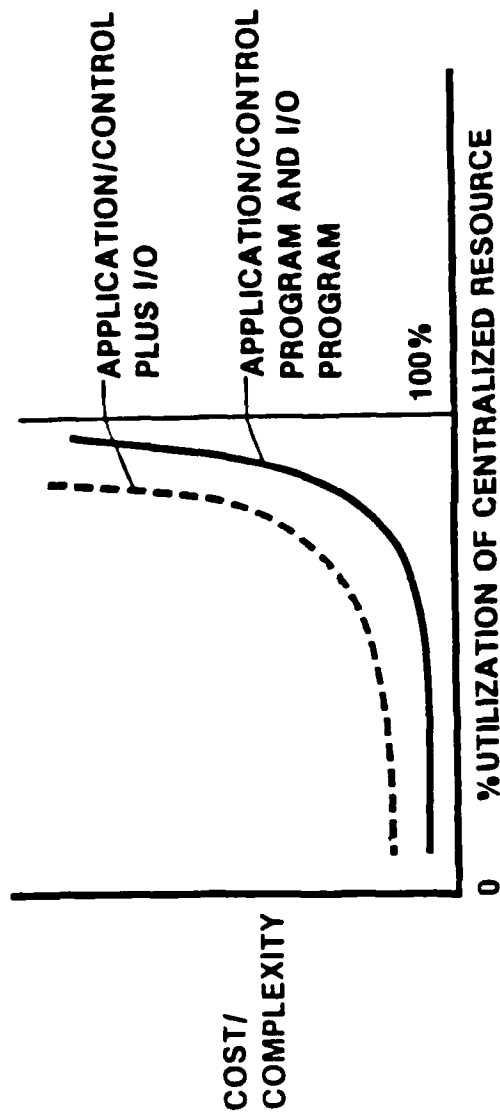

Figure 46. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 47. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(see Figure 47)

If one accpets as valid the projected number of microcomputers/

microprocessors projected for future naval aircraft/avionic

applications, than one can also expect that the activities of

the anthropomorphic figures shown will also take place. Specific-

ally, the various "scenes" taking place in Figure 47 are meant

to portray such common digital system situations such as: con

tention, idle resources, queing, and simultaneous multiple

accessing of common data bases.

Figure 48. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

CENTRALIZED PROCESSING ARCHITECTURE SOFTWARE COST/COMPLEXITY

Figure 49. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

COST/COMPLEXITY.

I/O PLUS
APPLICATION/
CONTROL

I/O CONTROL/
SCHEDULING

APPLICATION/
CONTROL
PROGRAM
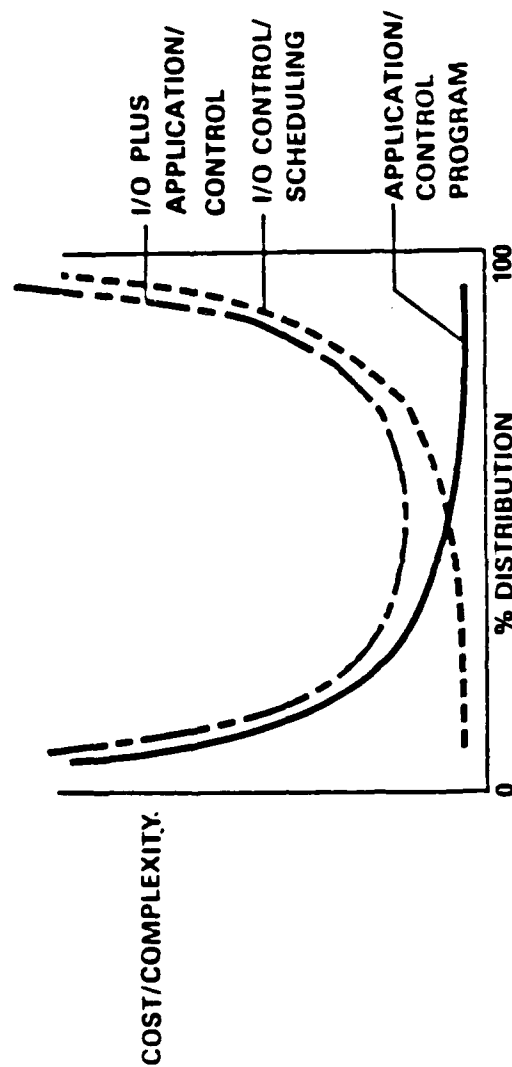
0   % DISTRIBUTION   100

- THE SUM OF THE TWO SOFTWARE TRENDS INDICATES A POINT OF DISTRIBUTION
  WHICH MAY BE OPTIMUM. FURTHER, AT EITHER END OF THE DISTRIBUTION
  SPECTRUM THE WORST OF BOTH WORLDS MAY EXIST!

DISTRIBUTED SYSTEM TRADEOFFS

Figure 50. "Optical Memory Storage Requirements and Applications for Use in Military
Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems
Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

DISTRIBUTED SYSTEM TRADEOFFS

(see Figure 50)

Figure 50 graphically displays how the cost/complexity of software goes down with an increasing percentage of distribution of the on-board embedded computer resources. This reduction in software cost/complexity is due to benefits that are inherent in a fully distributed system; for example: matching localized processing needs to performance requirements; independent and incremental growth; improved reliability due to modularization enforced by hierrarchical hardware decomposition; and computer power sharing that is readily available with the use of a high-speed bus structure.

Unfortunately, as the percentage of distribution increases, the problems associated with the software "overhead" has an overriding negative impact upon the attributes gained by going to a distributed network of embedded computer resources.

As can be seen graphically, the cost/complexity factor will reverse itself at some point, and again rise and couse to occur all of the traditional problems that have been experienced to date with software generation and its subsequent support.

The point at which the cost/complexity factor is fully minimized is, at this point in time, an unknown because there is very little experience with Real-Time, Computer-Controlled, Distributed Systems. Additionally, the ambiguity associated with the determination of the minimization of the cost/complexity factor is further complicated because advanced design concepts such as redundancy, reconfigurability, and fault-tolerance have not been taken into consideration in computing the cost/complexity factor.

Figure 51. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
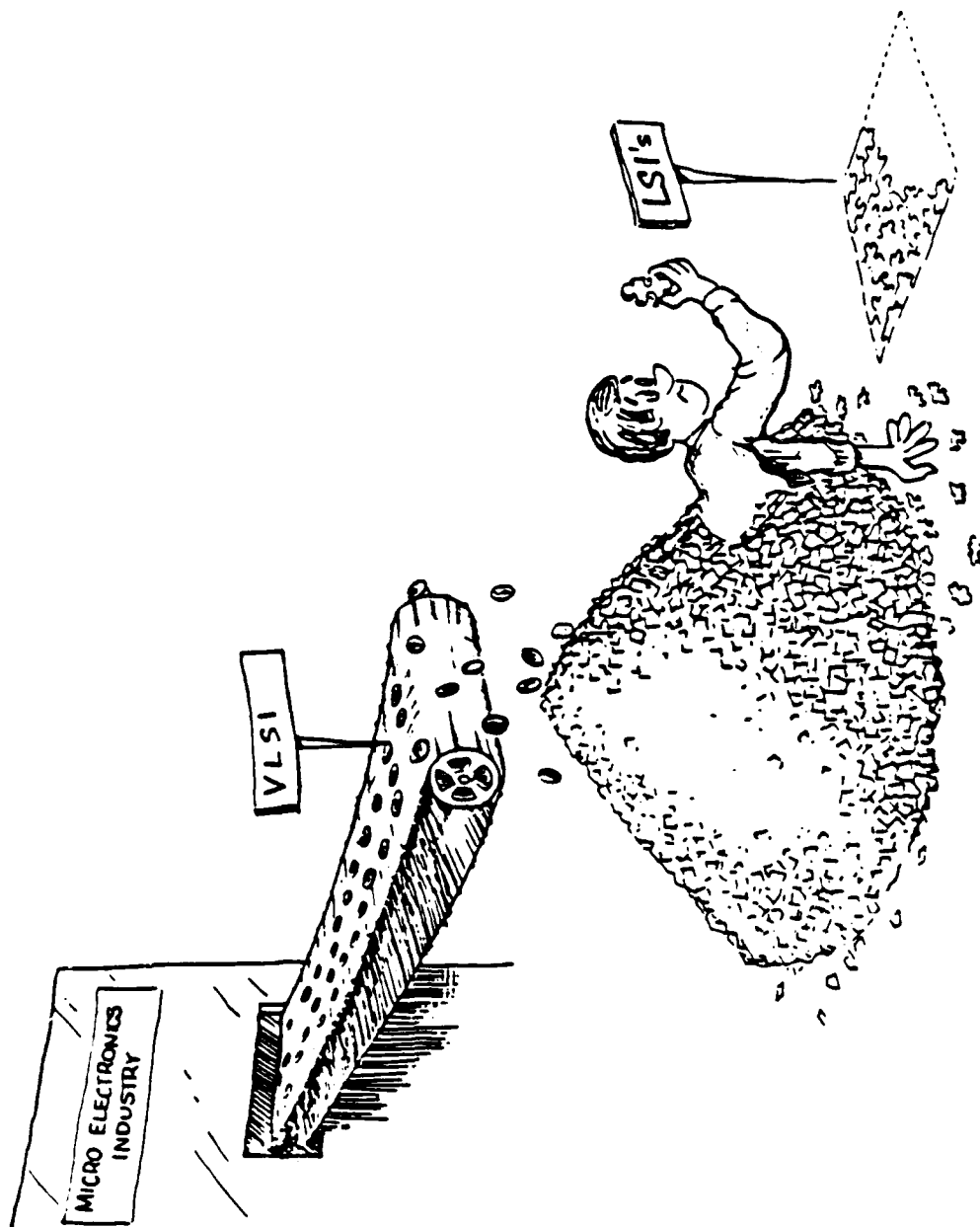
Figure 52. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(See figure 52)

If the aforementioned consideration of cost/complexity versus the degree of computer resources distribution gives technical managers headaches, and causes them many sleepness nights; their burden will increase if the introduction of new products from the world-wide solid-state (microelectronics) industry is allowed to continue unabated.

For example, while we have yet to determine how we will control the introduction and subsequent logistic support of Large Scale Integrated (LSI) circuits, the industry is on the verge of manufacturing Very High Speed Integrated Circuits (VHSICs). As is public knowledge, the VHSIC effort is being sponsored by the Department of Defense for sound management reasons: however, regardless of their inherent technical worth to the operational environment, the VHSIC chips will, as with all of its technology predecessors, add to the burden of logistic support in both the hardware and software arenas.
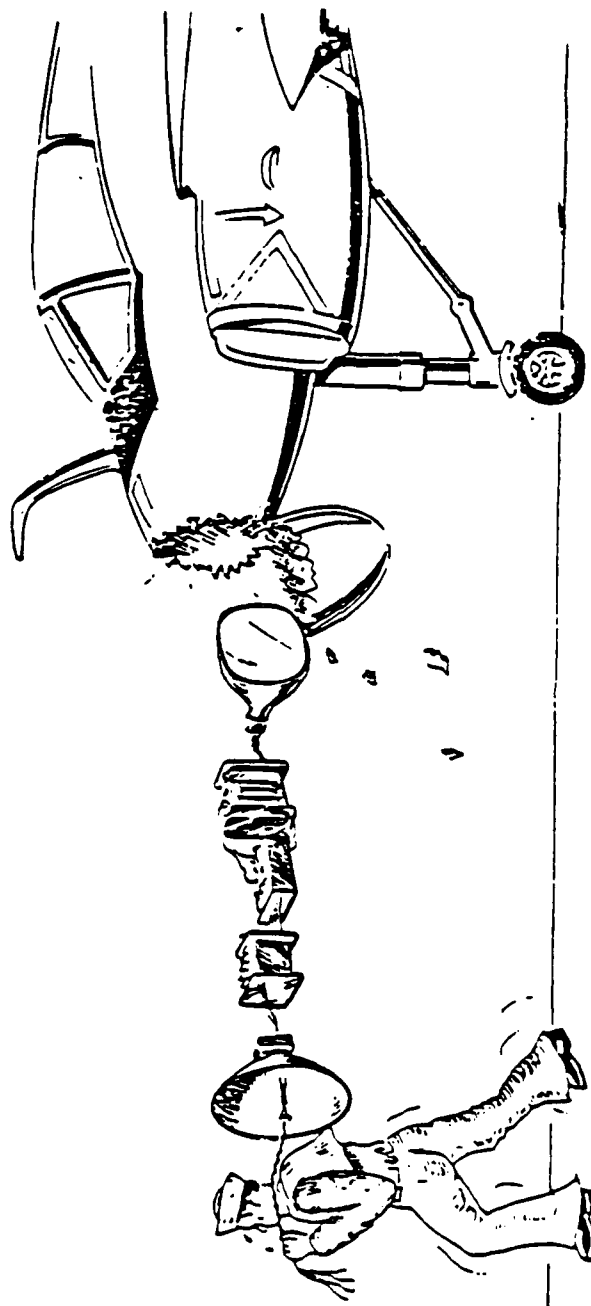
Figure 53. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
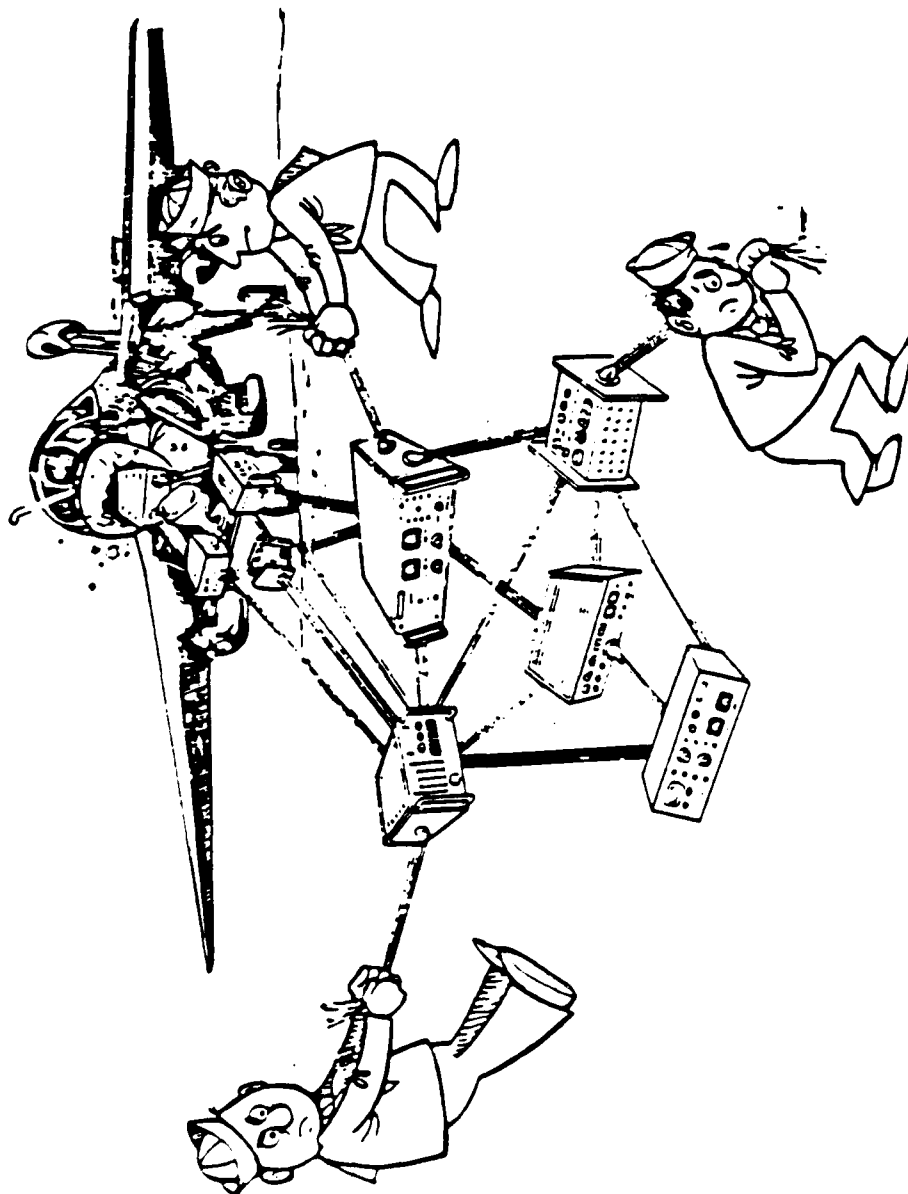
Figure 54. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(see Figure 54)

The purpose of this view graph (Figure 54) is to illustrate that prior to the introduction of higher density integrated circuits such as "Medium Scale Integration" (MSI) and "Large Scale Integration" (LSI), the maintenance technician could remove a particular component of an aircraft/avionic sub-system purely by visual recognition of the unit itself. That is, the degree of physical identity as to what role (factor) a particular "black box" played in the system was clearly identifiable in most cases by its physical characteristics. For example, the classical radar antenna in an aircraft has been mechanical in structure, and is rotated by mechanical motion. With future systems, one will find a fully solid-state technology antenna, which would be electronically scanned to provide the required coverage in both the azimuth and height directions. There will be little, if any, mechanical motion.

Figure 55. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPl, Washington, DC 20361-3500.

Figure 56. "Optical Memory Storage Requirements and Applications for Use In Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

(see Figure 56)

Figure 56 contrasts with the previous view graph in that it is a depiction of the future where the combination of high density solid-state electronic technology and modern electronic mechanical packaging concepts such as Standard Avionics Modules (SAMs) and Modular Avionics Packaging (MAP) will provide such a highly dense physical package with uniform overall dimensions that the capability to physically and electronically separate the parts of the system based on visual recognition will be negated and "become a thing of the past".

Figure 57. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
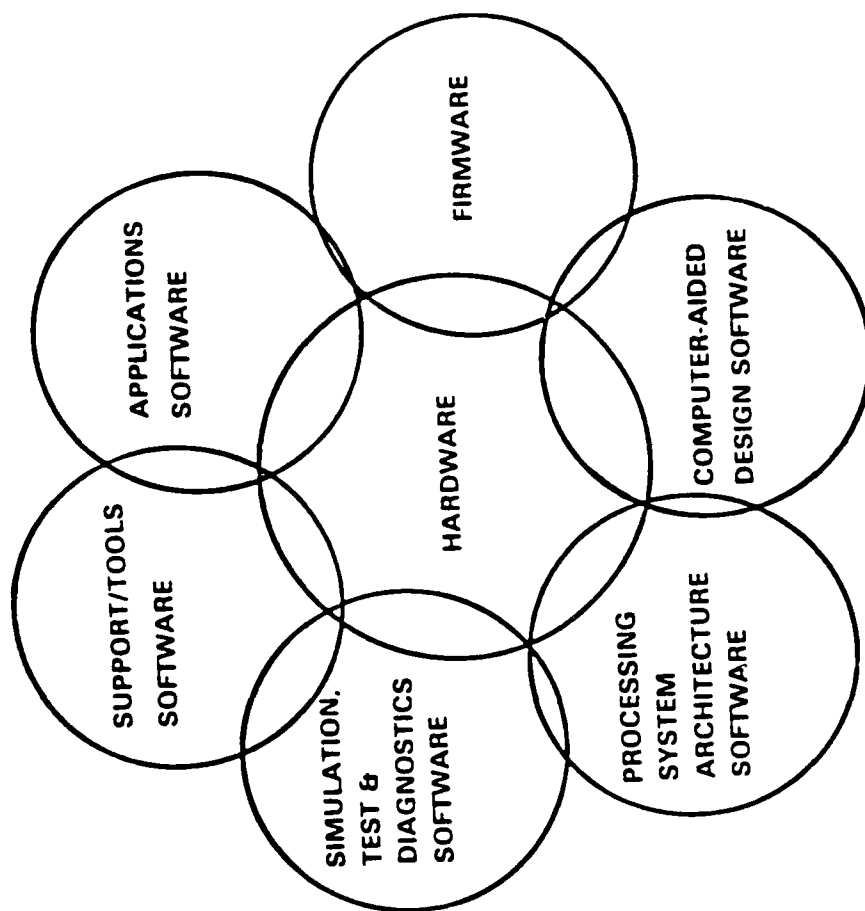
Figure 58. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

The circles in the diagram are labeled: APPLICATIONS SOFTWARE, FIRMWARE, SUPPORT/TOOLS SOFTWARE, HARDWARE, COMPUTER-AIDED DESIGN SOFTWARE, SIMULATION, TEST & DIAGNOSTICS SOFTWARE, PROCESSING SYSTEM ARCHITECTURE SOFTWARE.

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(see Figure 58)

The Real-Time, Computer-Controlled, Distributed System of the future will require that the system conceptual and definition phase of each future aircraft program consider the inter-relationships of the factors identified in Figure 58. While the technical partnership between the software and hardware has been recognized for sometime now, the growing scope of software implications beyond the operational applications programs and the associated software development tools has only recently been addressed with the same degree of rigor as was the recent effort associated with the definition of the Department of Defense's ADA High Order Language.

Figure 59. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JPl, Washington, DC 20361-3500.
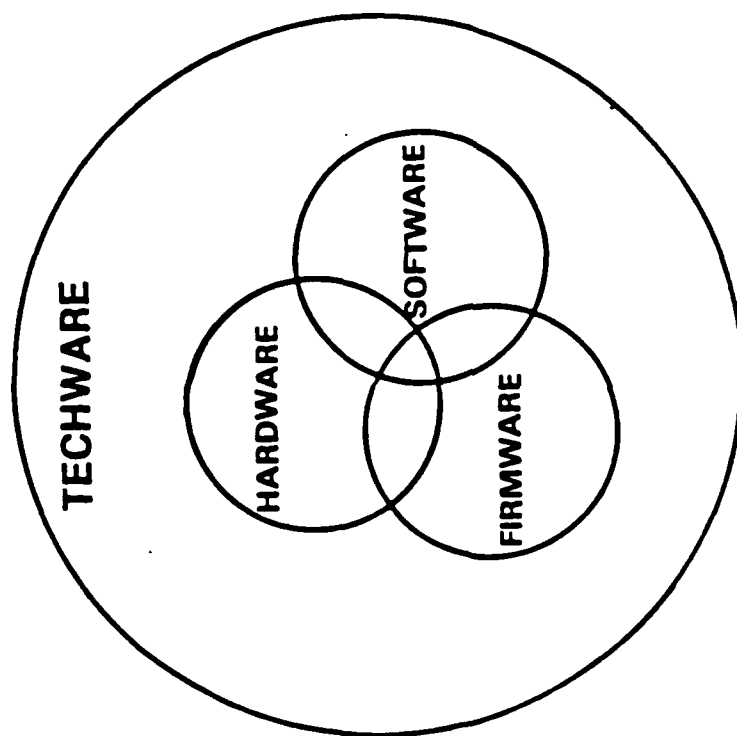
OMTR/77

Figure 60. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

TECHWARE
(see Figure 60)

I have recently reached the conclusion that the inter-
relationship of computer hardware, software, and firmware
is no longer inseparable, and therefore I propose that the
sum of these computer resource factors be addressed by a
term which clearly denotes the amalgamation of the three
distinct parts. For better or worse, I have picked the
term "TECHWARE" to identify this summation of the three
parts. In my definition, "TECHWARE is the combination
of solid-state technology and software and firmware which
results in a physically permanent product that performs an
operational, mathematical, and/or an engineering function."

Figure 61. "Optical Memory Storage Requirements and Applications for Use in Military
Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems
Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

CHALLENGES TO BE FACED

- AMOUNT OF EMBEDDING INTO THE SYSTEM ARCHITECTURE.

- SYSTEMS ENGINEERS NOT COMPUTER SPECIALIST/ENGINEERS PERFORMING THE DESIGN FUNCTION.

- PRIMARY FAILURES WILL BE AT THE SYSTEM LEVEL NOT AT THE COMPONENT LEVEL.

- LACK OF ECONOMIC LEVERAGE.

- RAPIDITY OF CHANGE IN THE MICROPROCESSOR STATE-OF-THE-ART.

- FIXED FUNCTION VS. PROGRAMMABLE MICROPROCESSORS.

- LACK OF PRECISE DEFINITIONS THROUGHOUT THE FIELD.

Figure 62. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

CHALLENGES TO BE FACED
(see Figure 62)

The items listed in Figure 62 represent my best judgment as to the challenges to be faced by the management and engineering staffs both in government and in industry involved in the system conception, definition, design, development, test and evaluation, and subsequent logistic support of future Real-Time, Computer-Controlled Distributed Systems for aircraft/avionic applications in the navy fleet arm of the future.

Figure 63. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

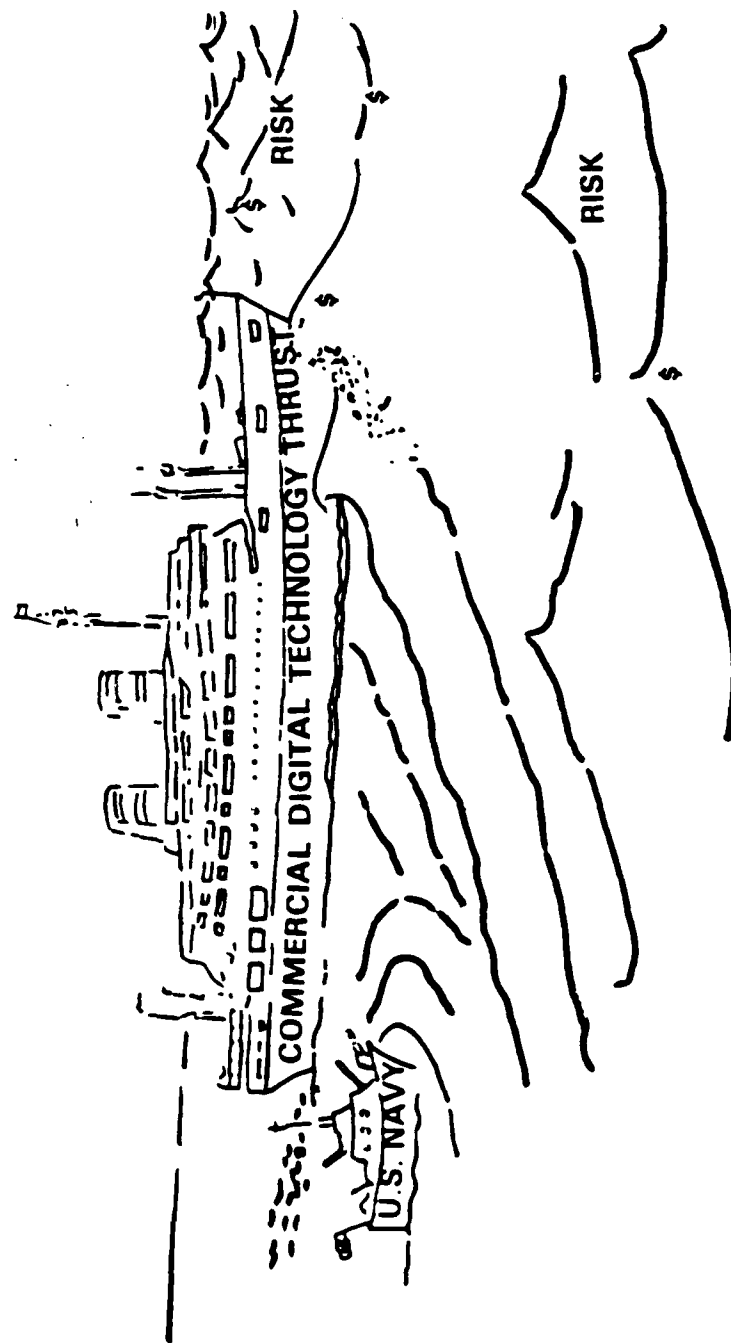ITS' ONLY A RANDOM FAILURE SIR! IT WILL NEVER HAPPEN AGAIN

Figure 64. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

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DIGITAL TECHNOLOGY
STRATEGY

Figure 65. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
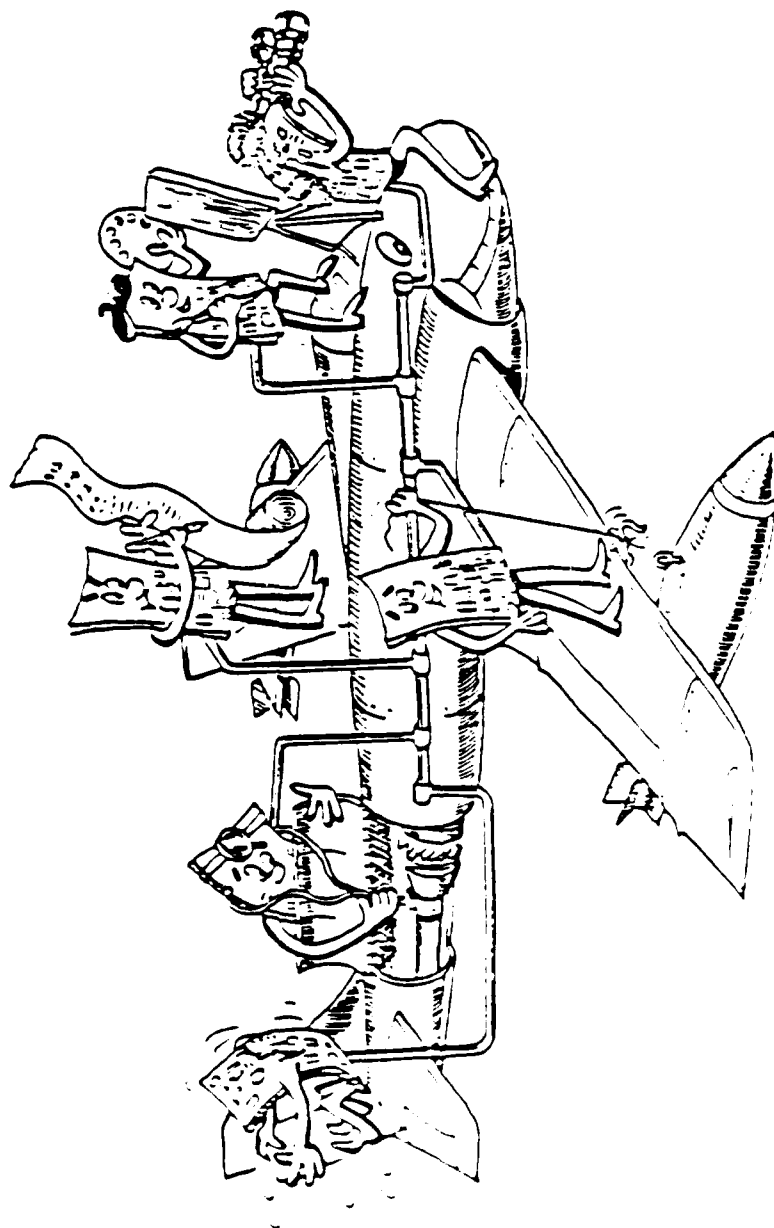
Figure 66. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 9350, Room 440, JP1, Washington, DC 20361-3500.

IF MANAGEMENT DOES NOT MANAGE

CHANGE, THEN CHANGE WILL

CHANGE MANAGEMENT

ANON.

Figure 67. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 68. "Optical Memory Storage Requirements and Applications for Use in Military Environments." Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
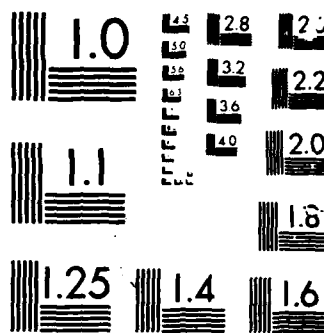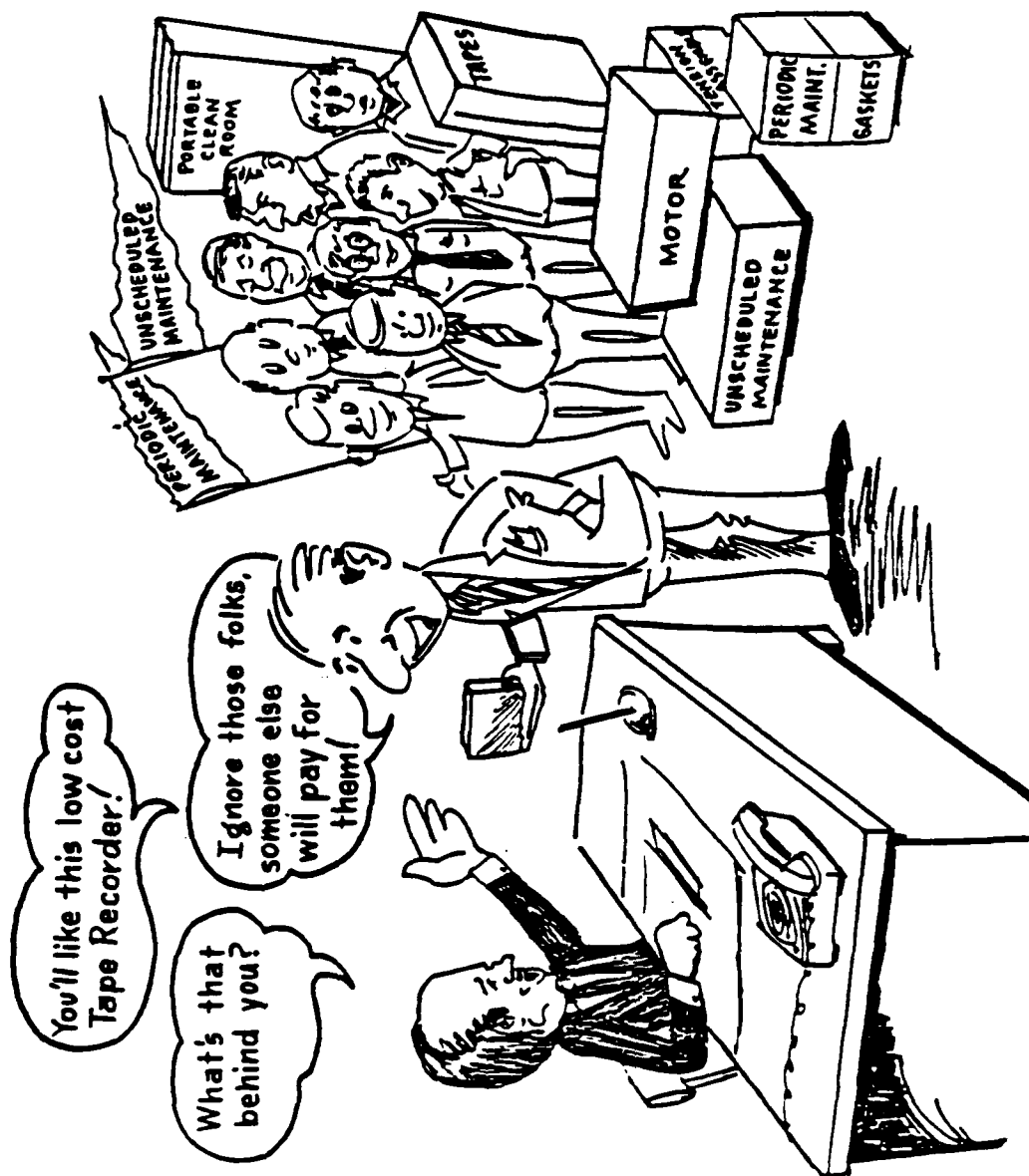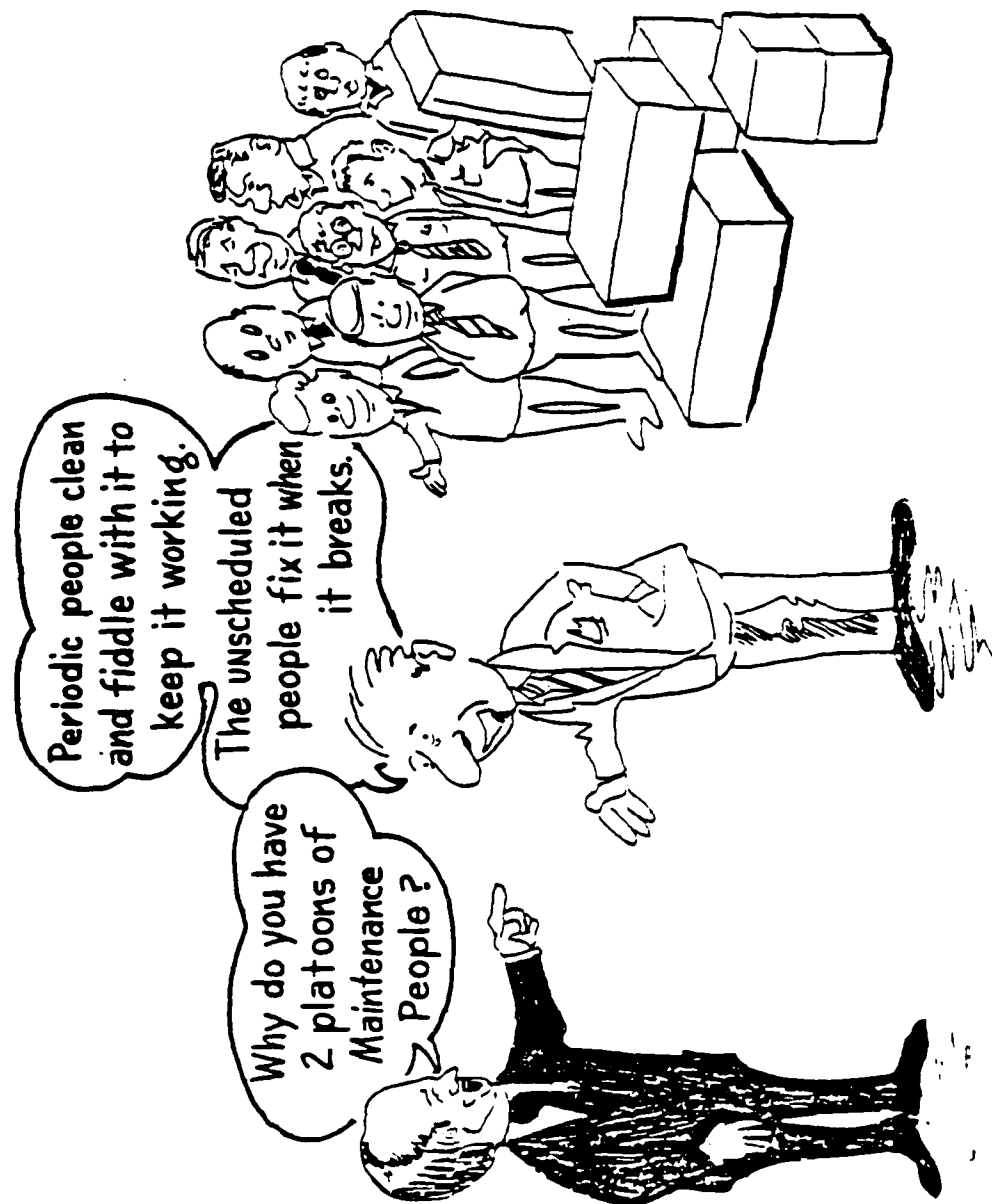
Figure 69. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR.935C, Room 440, JP1, Washington, DC 20361-3500.

1. A tape recorder salesman enters the office of a prospective client. He is extolling the virtues of his low cost tape recorder. Unfortunately, all of his maintenance people accompanied him on this visit.

2. Naturally, he is inquisitive about the need for two platoons of maintenance people. The periodic maintenance people perform the day-to-day routine preventive maintenance, cleaning tape heads, adjusting tape tension, replacing worn tapes, replacing gaskets, etc. This work would typically be done on the flight line. When the tape recorder has a component or subassembly failure either depot or factory personnel would repair these unscheduled failures. Hence two platforms of maintenance personnel are required.

3. Periodic maintenance can be deferred or eliminated but then the failure rate skyrockets. This happened with the P3 flight incident recorder.

4. Clearly, one can juggle the ratio of scheduled to unscheduled maintenance costs but it is a no win proposition.

5. A solid state recorder would cost a little more than a tape recorder, but it would require no scheduled maintenance. Eliminating moving parts would drastically reduce the unscheduled maintenance costs. Thus, a solid state recorder will minimize the total ownership cost to the user. However, initial cost is the major criteria in selecting recorders aboard aircraft regardless of life cycle costs. Thus, tape recorder companies could sell the tape recorder for one dollar and make money in the maintenance of the recorders. Of course a $1 tape recorder would delight the procurement personnel. Since solid state recorders are virtually maintenance free, the initial cost cannot be transferred to maintenance costs. Hence a life cycle cost approach to procurement must be taken if reliable cost effective hardware is desired.

Figure 70. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

88/OMTR
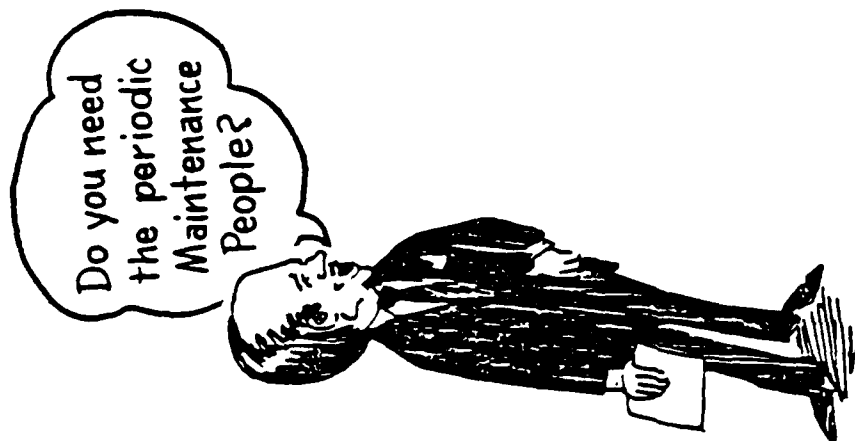
Figure 71. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.

Figure 72. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
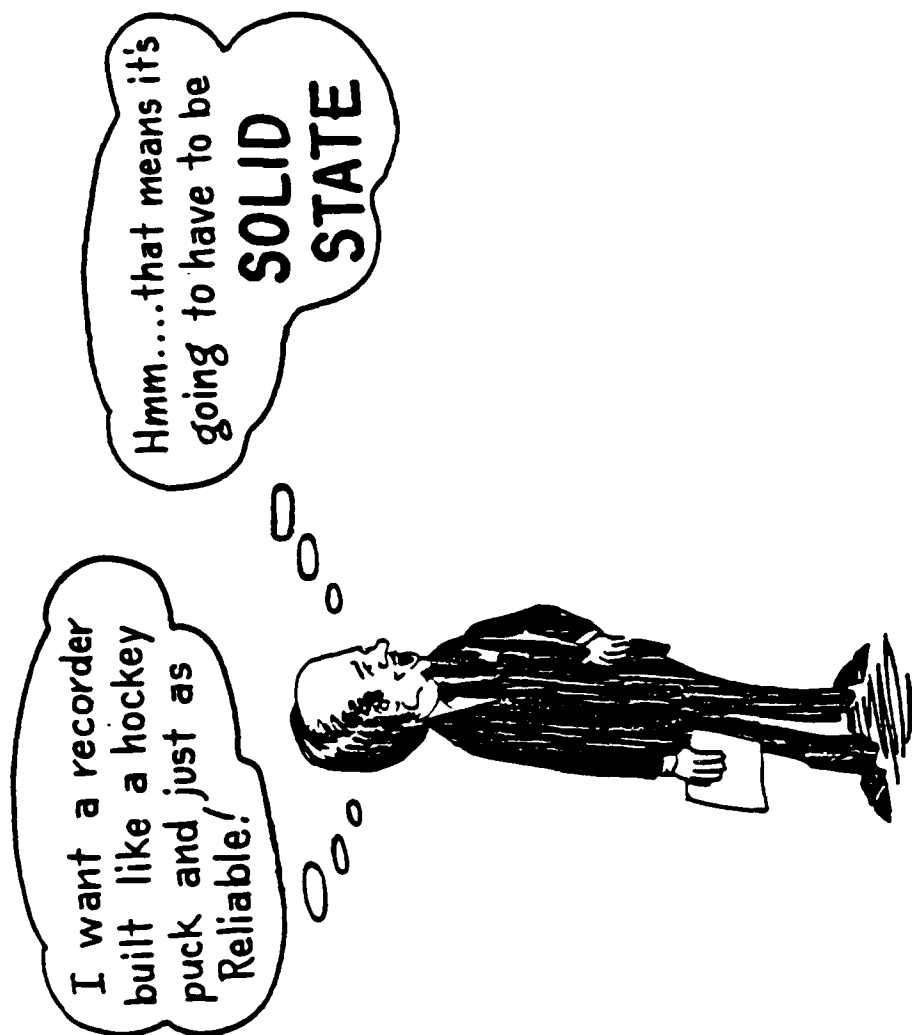
Figure 73. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
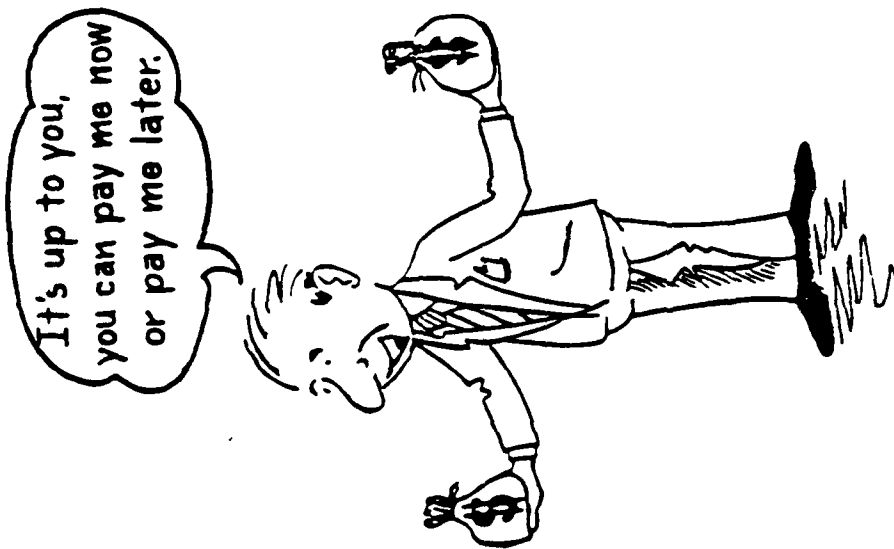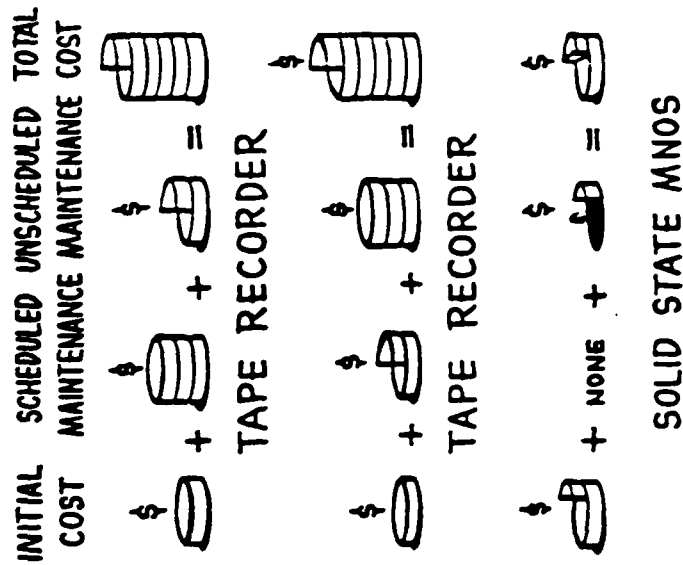
Figure 74. "Optical Memory Storage Requirements and Applications for Use in Military Environments," Bernard A. Zempolich, US Dept of the Navy, Naval Air Systems Command, AIR 935C, Room 440, JP1, Washington, DC 20361-3500.
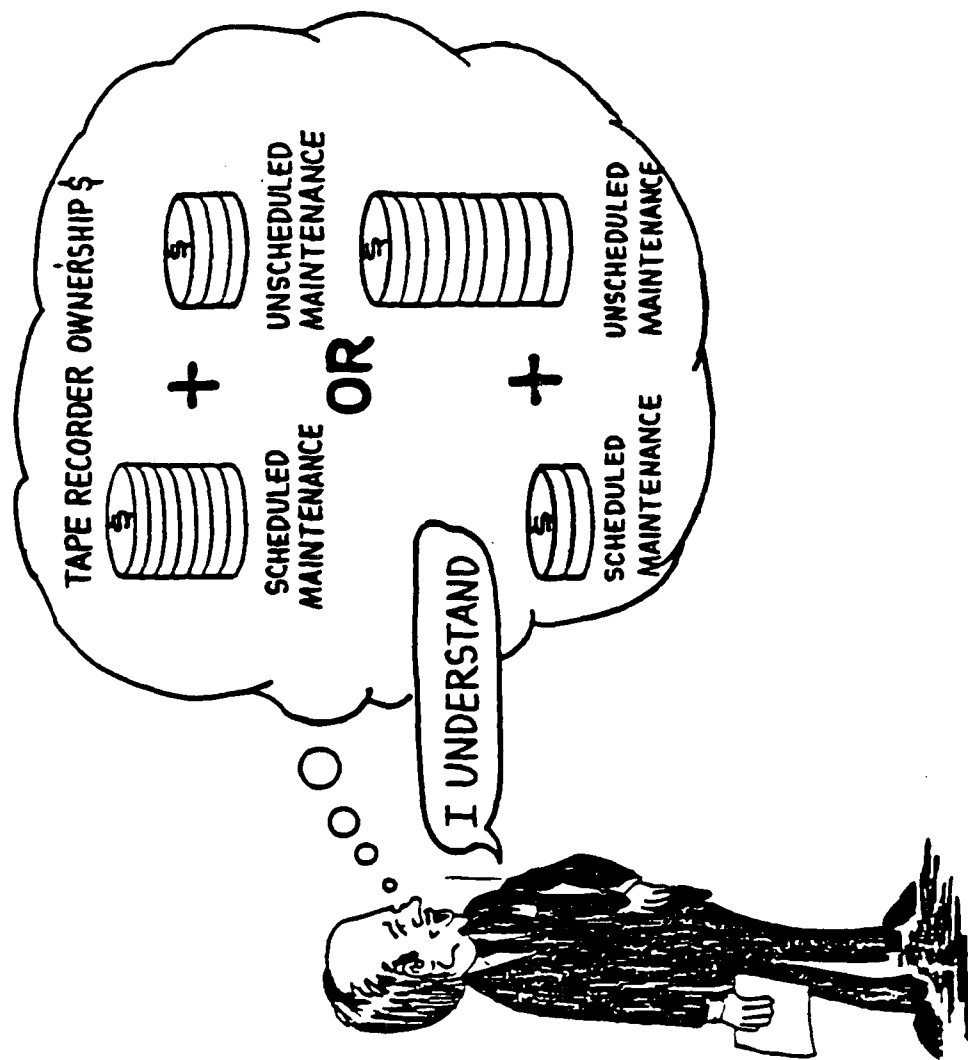
5.25" OPTICAL DISK DRIVE MANUFACTURERS

	MEDIA SOURCE	STATUS
US:		
OPTOTECH	DAICEL CHEMICAL	1
	OSI	
	PLASMON	
	3M	
ISI	SUMITOMO CHEM	1
OSI	OSI	4
OPTIMEM	ATG	3
	3M	
CHEROKEE	PLASMON	4
	3M	
LASER DRIVE	–	4
JAPAN:		
TOSHIBA	–	2
HITACHI	–	3
RICOH	–	4
SONY	–	3
SANYO	–	3
CANON	–	3
SHARP	–	3
MITSUBISHI	–	4
MATSUSHITA	–	4
FUJITSU	ASAHI CHEM	4
NEC	–	4
JVC	–	4
PIONEER	–	4
EUROPE:		
PHILIPS	OSI	4

1-IN PRODUCTION,   2-DELIVERED BETA UNITS,
3-DEMONSTRATED EXPERIMENTAL UNIT,
4-UNDER DEVELOPMENT

Figure 1. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 wooten Road, Colorado Springs, CO 80915-3513.

5.25" WORM MEDIA SOURCES

	STRUCTURE	WRITING PROCESS	SENSITIVE LAYER
Asahi Chemical	Monolayer	Ablation	Te Alloy
ATG	Trilayer	Bubble forming	Te Alloy
Canon			
Daicel	Monolayer	Ablation	Te Alloy
Dainippon Ink	Monolayer	Maxwell Garnett	$Sn-SnO_2$
Fuji Photo Film	Monolayer	Ablation	Dye Polymer
Fujitsu	Monolayer	Ablation	(Asahi)
Hitachi	Monolayer	Ablation	TeSe (SnSbPb)
Matsushita		Phase Change	TeO_x
Mitsui Toatsu	Monolayer	Ablation	Dye Polymer
OSI	Monolayer	Ablation	Te Alloy
Plasmon	Moth Pattern	Ablation	Pt Alloy
Ricoh	Monolayer	Deformation	Organic
Sanyo	Monolayer	Ablation	Te Alloy
Sony	Multilayer	Alloying	Sb_2SE_3/Bi_2Te_3
Sumitomo Chemical	Monolayer	Ablation	Te Alloy
TDK	Monolayer	Ablation	NISC Dye
Toshiba	Monolayer	Ablation	TeC

Figure 2. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

APPLICATIONS:

ARCHIVAL UPDATABLE DATA STORE:

ON-LINE: -Small business database
-Personal computer database

OFF-LINE: -Medical records and images
-Financial records
-Legal records
-Maps and navigation records
-Security sensitive data

DISK BACK-UP:

-Winchester disk back-up with
random access capability

ELECTRONIC PUBLISHING:

-Updatable publication
-Updatable software distribution

IN FIELD MASS DATA ACQUISITION:

-Seismic data acquisition
-Earth resources data acquisition
-Reconnaissance data acquisition

HARSH ENVIRONMENT APPLICATIONS:

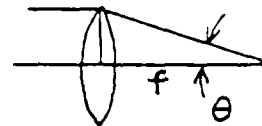-Radiation hardening
-Extreme temperature
-Extreme EMI

Figure 3. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

FOCUSED LASER BEAM DIAMETER S AT
FULL-WIDTH-HALF-MAXIMUM (FWHM)

$$S = 0.5 \frac{\lambda}{n.\,a.}$$

where n. a. is the numerical aperture of the lens

$$n.\,a. = \sin \theta$$

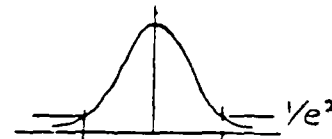For uniform illumination, the Airy disk diameter is

$$d = 1.22 \frac{\lambda}{2\,n.\,a.}$$

For Gaussian beam profile, the $1/e^2$ point diameter is

$$d = (4/\pi) \frac{\lambda}{2\,n.\,a.}$$

TYPICAL VALUES:

$$\lambda = 800 \text{ nm}$$
$$n.\,a. = 0.5$$
$$S = 0.8 \text{ um}$$

Figure 4. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

Current commercially available laser diodes and their characteristics.

Laser structure	Wave length (nm)	Power output P_cw (mW)	Power output P_pulsed 50ns	Threshold current I_{th} (mA)	Efficiency (mW)	Beam divergence $\theta_\parallel$	Beam divergence θ_T	Astigmatism Z (μm)	Polarization ratio numerical aperture = 0.50	Spatial mode (profile)	Axial mode (spectral)
CSP	820 to 850	20	25	55	0.25 to 0.4	12°	30°	5	20:1	Near Gaussian	Single
CSP	800 to 830	7	10	30	0.36	11°	40°	–	–	Near Gaussian	Single
TJS	800 to 830	15	15	25	0.4 to 0.5	9°	32°	5	40:1 (1mW)	Near Gaussian (extra peak)	Single
TS	800 to 830	15	15	28	0.4 to 0.5	14°	40°	5	–	Near Gaussian	Single
DH (Single M)	820 to 850	5	5	65	0.3	12°	40°	–	30:1 (2mW)	Near Gaussian	Single
SML	770	5	55	70	0.3	10°	36°	–	–	Near Gaussian	Single
LOC/CDH	800 to 830	20	40	100	0.4	10°	30°	8	60:1 (40mW) pulsed	Near Gussian	Single
DH multi M	800 to 850	5	50	100	0.17 (cw) 0.4 (pulsed)	34°	60°	12 to 35	5:1 (1 mW)	"Rabbit ears"	Multiple
V groove	780 to 800	20	20	100	0.20	30°	60°	–	–	"Rabbit ears"	Multiple

Figure 5. "Status of 5.25-Inch Optical Digital Data Disk Technology." Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.
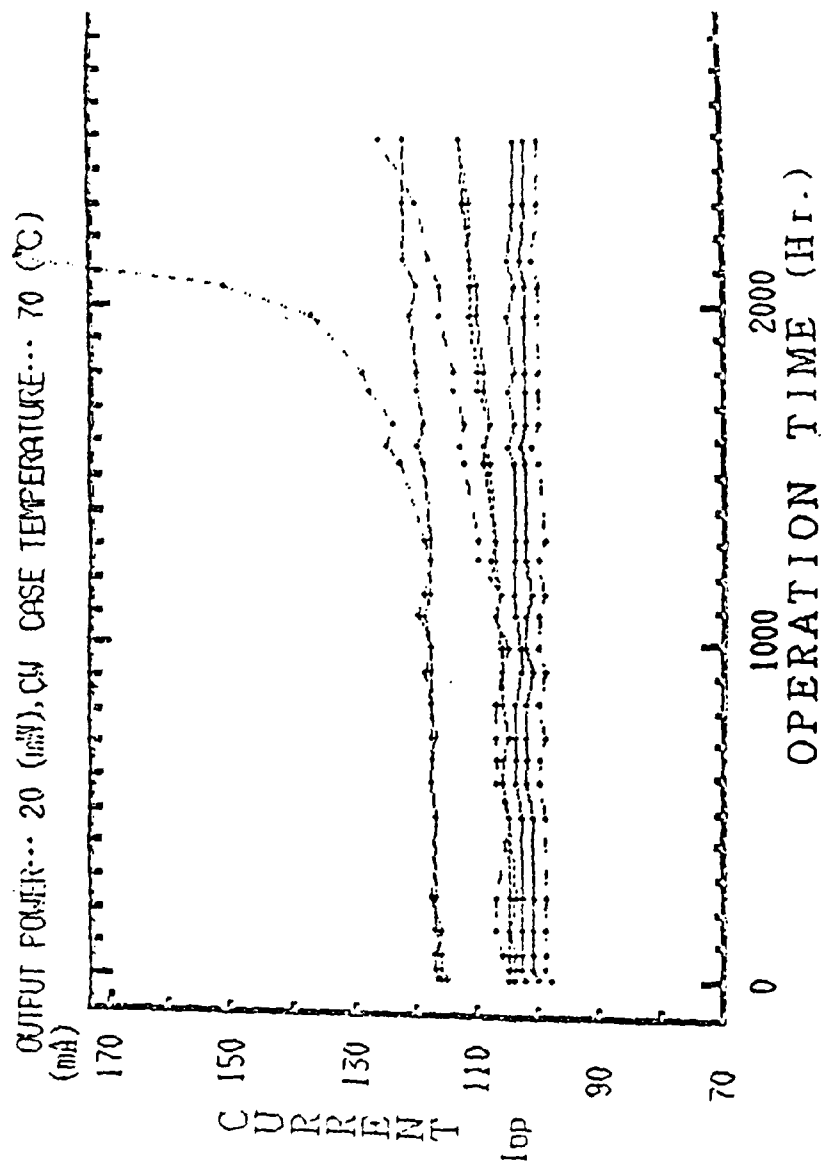
Figure 6. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.
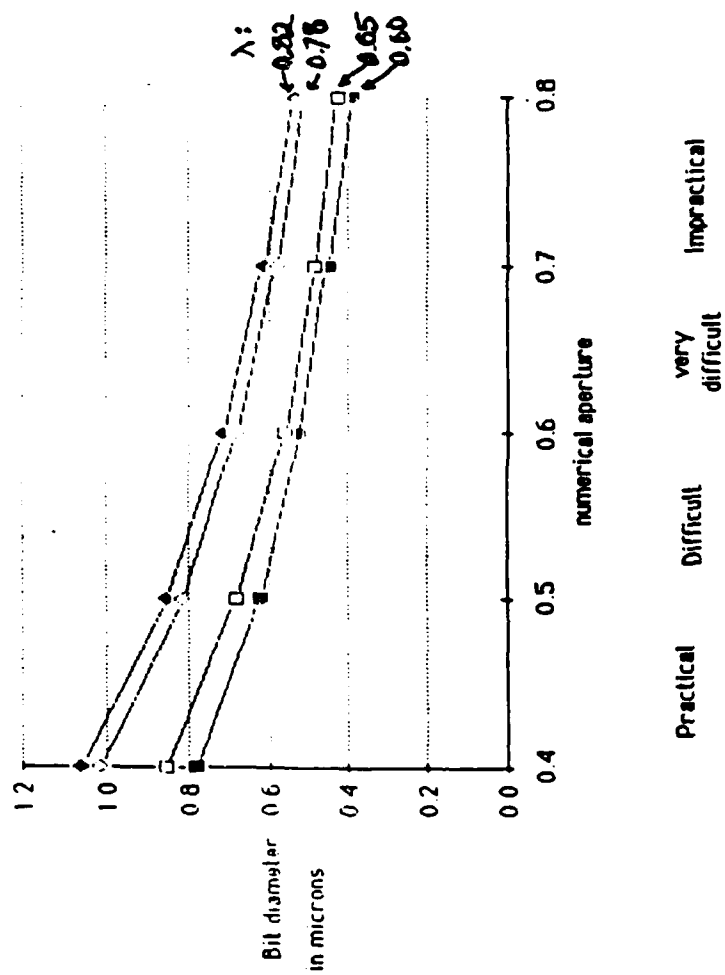
Figure 7. "Status of 5.25-inch Optical Digital Data Disk Technology." Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

<u>RECORDING CAPACITY.</u>

(1) BIT SIZE.
      LIMITED BY: *OPTICS
                       *LASER DIODE WAVELENGTH
                       *BIT BOUNDARY STABILITY
                       *MINIMUM DOMAIN SIZE FOR M-O
     PRESENT STATUS.   0.8 TO 1.0 UM BIT DIAMETER FOR
                       WORM AND 1.0 TO 1.5 UM FOR M-O

(2) BIT SPACING
      LIMITED BY :   * ADJACENT BIT INTERFERENCE
                       * PEAK SHIFT
                       * BIT BOUNDARY STABILITY

     PRESENT STATUS.   1.5 TIMES THE BIT SIZE

RESULTING AREAL DENSITY: 44 TO 69 MBITS/SQ. CM.
                               FOR WORM
                               20 TO 44 MBITS/SQ. CM.
                               FOR M-O

FOR AN ANSI STANDARD 5.25 " OPTICAL DISK, AT
CONSTANT LINEAR DENSITY, THE RAW BIT CAPACITY
IS 466 TO 730 MAGABYTES PER DISK SIDE FOR WORM,
212 TO 466 MAGABYTES PER DISK SIDE FOR M-O.

<u>Figure 8.</u> "Status of 5.25-incn Optical Digital Data Disk Tecnnology," Di Chen,
            Optotecn, 740 Wooten Road, Colorado Springs, CO 80915-3518.

LASER DIODE POWER OUTPUT VS DATA RATE

(1) HEATING OF THE SENSITIVE LAYER FOR HOLE FORMING:
$$P(1) = A \ T \ / \ t$$

(2) HEATING OF THE SUBSTRATE
$$P(2) = B \ T \ / \ \sqrt{t}$$

WRITING POWER ON THE RECORDING MEDIA
$$P = P(1) + P(2) = (A \ / \ t \ + B \ / \sqrt{t} \ ) \ T$$

FOR Te ALLOY FILM ON PC SUBSTRATE, THE REQUIRED
POWER IS EMPERICALLY GIVEN AS
$$P \ (mW) = 0.26 \ /t \ + \ 2/ \ \sqrt{t} \qquad t \ in \ usec.$$

At 2 MHz date rate, using a 100 nsec pulse, the required
laser power ON THE RECORDING MEDIA is 9 mW. the
required power is 46 mW at 20 MHz.

Figure 9. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen,
Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.
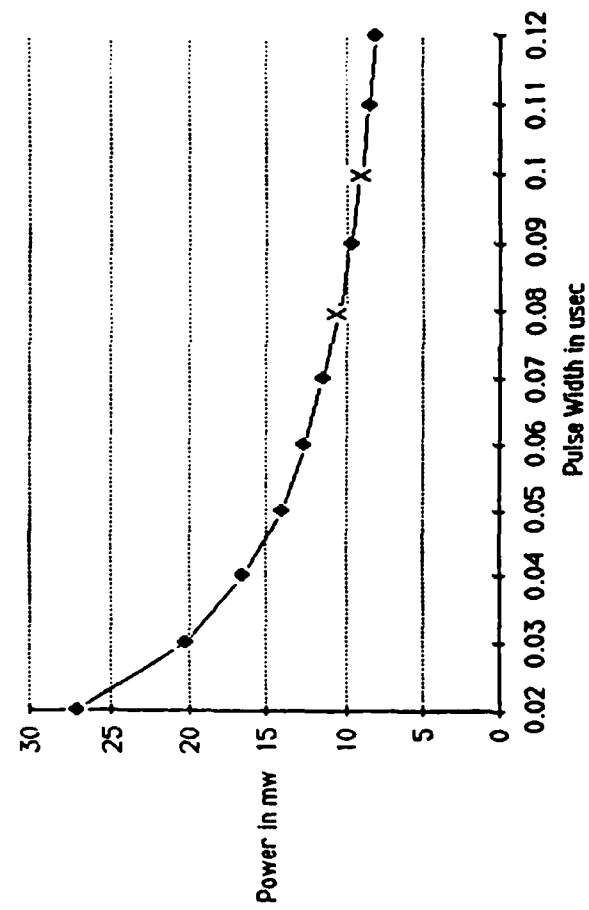
Figure 10. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Sprinys, CO 80915-3518.

DATA RATE

(1) WRITE POWER
     LIMITED BY   * AVAILABLE LASER POWER
                   * BEAM INTENSITY TRANSMISSION
                     EFFICIENCY IN OPTICAL HEAD
     PRESENT STATUS   *MAXIMUM PEAK LASER DIODE
                     POWER OUTPUT = 30 MW
                     *TYPICAL BEAM INTENSITY
                     TRANSMISSION EFFICIENCY = 50 %
                     for WORM and 35% for M-O
                     *MINIMUM WRITE PULSE LENGTH
                     IS 40 NSEC.

(2) BIT ELONGATION:

Linear on track velocity of current optical disks falls in
the range of 15 to 3.7 m/sec.

Bit elongation = Linear velocity x Write pulse length

1.20	um	15.0 m/sec	0.08 usec
0.60		7.5	0.08
0.30		3.7	0.08
0.30		7.5	0.04

*Bit elongation causes reduction in aeral density.
*Reduction in pulse length means higher laser power.
*Current laser power of 30 mw output or 15 mw on the
  disk means that the pulse width is limited to no less
  than 0.04 usec. using common WORM or M-O media.
*Allowing 0.3 um bit elongation means that 7.5 m/sec. is
  the upper limit of the linear velocity.
*At a bit spacing of 1.5 um bit spacing , this yields the
  upper limit of the raw data rate of 5 magabit/sec. This
  represents the lower range for WORM and upper range
  for M-O

Figure 11. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen,
         Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

ACCESS TIME:

(1) SEEK TIME:
  LIMITED BY: *WEIGHT OF THE OPTICAL HEAD
        *FOCUSING AND TRACKING ACTUATOR
         STABILITY
        *POWER REQUIREMENT OF SEEK
         ACTUATOR
  PRESENT STATUS: 150 msec FOR STEPPER MOTOR
         50 msec FOR LINEAR MOTOR IN
         5.25" OPTICAL DISK DRIVES

(2) ROTATIONAL LATENCY TIME:
  LIMITED BY: *ALLOWABLE LINEAR VELOCITY FOR
        WRITING
        *DISK SUBSTRATE MATERIAL
        TOLERANCE
  PRESENT STATUS: 16.7 TO 50 msec average

(3) MOTOR SPEED SETTLING TIME (FOR CONSTANT LINEAR
  VELOCITY CASE ONLY)
  PRESENT STATUS: 1 TO 3 sec.

Figure 12. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3513.

MAGNETO-OPTIC RECORDING STATUS

COMPANY	MATERIAL	S/N	R/W RATE-MHZ	SUBSTRATE
KDD	Tb Fe Co	52	0.5-9	PMMA
SONY	Tb Fe Co	52	0.5-9	PMMA
OLYMPUS	Gd Tb Fe	49	0.5-9	PMMA
SHARP	Gd Tb Fe	43	2	ETCHED-GLASS
MATSUSHITA	Gd Tb Fe Ge	49	0.5-9	GLASS -2P
NHK	Gd Tb Co	40	3-6	GLASS
RICOH	Tb Fe Co	45	1	GLASS
PHILIPS	Gd Tb Fe	30	0.125	GLASS
XEROX	Tb Fe	37	1-10	GLASS
3M	RE - TM	>50	1-10	GLASS
NIKON	TbFe-GdFeCo	55	1	GLASS

Figure 13. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

SIGNAL-TO-NOISE RATIO

(1) WORM MEDIA

    LIMITED BY: * SENSITIVE LAYER GRAIN NOISE
                   * SUBSTRATE SURFACE NOISE
                   * STAMPER AND REPLICATION
   INTRODUCED FIXED PATTERN NOISE
                   * OTHER DEFECTS

  PRESENT STATUS: S/N = 60 DB AND BER = 10 EXP(-5)
                     IS TYPICAL AT BEGANING OF LIFE,
                     S/N IS LIMITED BY NOISE

(2) M-O MEDIA

    LIMITED BY   *LOW M-O EFFECT
                 *SENSITIVE LAYER NOISE
                 *STAMPER AND REPLICATION INTRODUCED
                  NOISE
                 *SUBSTRATE SURFACE NOISE
                 *OTHER DEFECTS

  PRESENT STATUS: S/N = 50 DB AND BER = 10EXP(-5)
                     IS TYPICAL AT BEGANING OF LIFE
                     S/N IS LIMITED BY LOW SIGNAL
                     LEVEL

Figure 14. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen,
               Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.
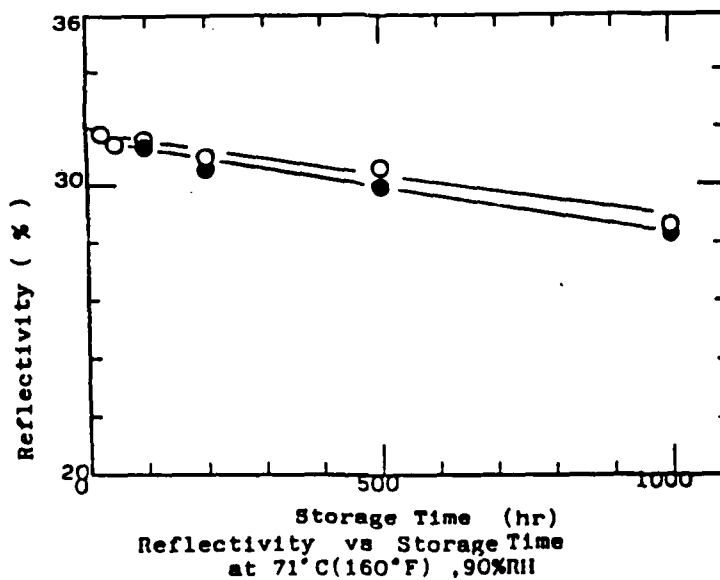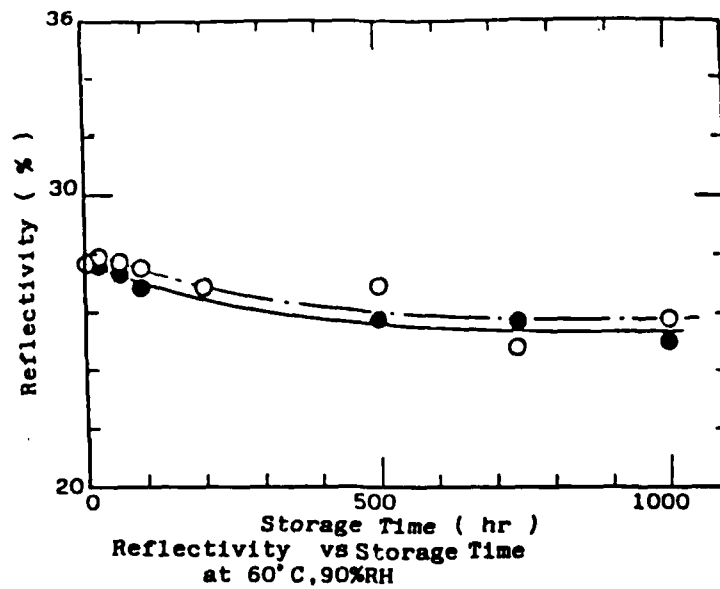
ENVIRONMENTAL TEST DATA FOR 5.25" OPTICAL DISKS WITH
POLYCARBONATE SUBSTRATE AND Te ALLOY SENSITIVE LAYER

Figure 15. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen,
Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

STABILITY

(1) BIT BOUNDARY STABILITY:

    FOR M-O MEDIA :   *DOMAIN WALL STABILITY MUST BE
                              ASSURED UNDER
                              (A)WRITE/ERASE FIELD,
                              (B) OPERATING TEMPERATURE
                                  EXTREMES*,
                              (C)ADJACENT BIT HEATING.

    FOR WORM MEDIA: *NO KNOWN BIT BOUNDARY
                              INSTABILITY FOR Te ALLOY

(2) MEDIA DEGRADATION:

    FOR M-O MEDIA :   *M-O LAYER MUST BE PROTECTED
                              *DEGRADATION CAN BE RETARDEED
                              BY ALLOYING WITH ADDITIVES OR
                              COATING WITH A PROTECTIVE
                              LAYER DEGRADATION APPEARS
                              TO GROW FROM EXISTING DEFECTS.

    FOR WORM: *Te IS NOT STABLE BUT TeSe
                              COMPOUND IS REASONABLY
                              STABLE. DEGRADATION
                              INTRODUCES MOSTLY SINGLE BIT
                              DEFECTS

    PRESENT STATUS.   *FIVE YEARS WRITE AND TEN
                              YEARS READ LIFE FOR WORM,
                              TWO TO FIVE YEARS LIFE FOR M-O.

* OPERATING TEMPERATURE RANGE ACCORDING TO THE
ANSI STANDARD IS FROM 10 TO 50 DEGREES CENTIGRADE.

Figure 16.   "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen,
            Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3513.

	WORM	MO CompPt.	CuriePt.
DENSITY	good	poor	fair
WRITEPOWER	fair	good	fair
DRDW	good	poor	poor
S/N	good	fair	fair
STABILITY	good	poor	fair
TEMPERATURE RANGE	good	poor	good
ERASIBILITY	no	yes	yes

good

fair

poor

Figure 17. "Status of 5.25-inch Optical Digital Data Disk Technology," Di Chen, Optotech, 740 Wooten Road, Colorado Springs, CO 80915-3518.

CONCLUSION:

(1) WRITE-ONCE-READ-MOSTLY OPTICAL RECORDING
    TECHNOLOGY IS MATURING. 5.25" OPTICAL DISK DRIVES
    WITH THE FOLLOWING PERFORMENCE IS NOW READILY
    AVAILABLE:
        *CAPACITY (MBYTE/SIDE)   200
        *DATA RATE (MBITS/SEC)   2.2
        *ACCESS TIME (mSEC)   200
        *MEDIA LIFE (YEARS)   5 (WRITE), 10 (READ)

(2) PERFORMANCE LIMITATIONS BASED ON CURRENT
    TECHNOLOGY FOR THE 5.25" DRIVES ARE AS FOLLOWS:
        *CAPACITY (MBYTES/SIDE)   600
        *AVE. ACCESS TIME (mSEC)   50
        *DATA RATE (MBITS/SEC)   5
        *MEDIA LIFE (YEARS)   20

(3) WRITE-ONCE-READ-MOSTLY OPTICAL STORAGE
    DEVICES AND WINCHESTER DRIVES COMPLIMENTS EACH
    OTHER. THEY CAN BE TEAMED TO MAKE A POWERFUL
    MEMORY SYSTEM WHICH OFFERS HIGH ACCESS TIME,
    REMOVABLE CARTRIDGE, ERASABLE DATA AND
    PERMINENT DATA STORAGE.

(4) 5.25" DRIVE FORM FACTOR IS SUITED FOR NOT ONLY
    THE PC AND MINI COMPUTER MARKET, BUT ALSO JUKE
    BOX APPLICATIONS AS WELL BECAUSE THE EASE OF
    DISK TRANSPORT AND HIGHER VOLUME PACKING
    DENSITY AS COMPARED TO SYSTEMS USING 12" DISKS.

(5) MAGNETO OPTIC CURIE-POINT RECORDING TECHNIQUE
    IS THE BEST CANDIDATE FOR ERASABLE OPTICAL DATA
    STORAGE. HOWEVER, THE MEDIA STABILITY PROBLEM
    IS NOT ANTICIPATED TO BE SOLVED UNTIL 1988.

Figure 18. "Status of 5.25-inch Optical Digital Data Disk Technology." Di Chen,
            Optotech, 740 Wooten Road, Colorado Springs, CO 90915-3518.

R FAIRCHILD

OUTLINE:

- PRINCIPLE DOD SPECIFICATIONS

- COMPARISON OF ENVIRONMENTAL REQUIREMENTS FOR EQUIPMENT LAND, SEA, AND AIR

- DISK DRIVE PACKAGING METHODS TO ACHIEVE ENVIRONMENTAL REQUIREMENTS

  OVERALL PACKAGING CONSTRAINTS

  THERMAL CONSIDERATIONS

  VIBRATION AND SHOCK CONSIDERATIONS

- RESULTING ENVIRONMENTAL AND DESIGN REQUIREMENTS OF OPTICAL DISK DRIVES

Figure 1. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

SPECIFICATIONS AND STANDARDS OUTLINE
FOR MILITARY ELECTRONICS EQUIPMENT

◼ FAIRCHILD
COMMUNICATIONS AND ELECTRONICS COMPANY

MIL-E-5400	MIL-E-16400	MIL-E-4158
AIRBORNE	NAVAL SHIP	LAND USE
	OR SHORE	

● PRINCIPLE SPECIFICATIONS

● COMMON OUTLINE

1.0 SCOPE (5400 ALSO DEFINES TEMPERATURE CLASSES)

2.0 APPLICABLE DOCUMENTS

    LIST OF ALL SPECS AND STANDARDS REFERENCED

    FREQUENT REFERENCES TO MIL-STD-454

3.0 REQUIREMENTS

    DETAILED DESIGN DIRECTION: SPRINGS, SOLDERING, MOUNTING, PRESSURIZATION ...

    SERVICE CONDITIONS: VIBRATION, SHOCK, TEMPERATURE ...

4.0 QUALITY ASSURANCE

    TESTING - REFERENCES TO TEST DOCUMENTS: MIL-STD-810 (ENVIRONMENTAL)

                                               MIL-STD-462 (EMI)

                                              OTHERS

Figure 2. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

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OFTEN USED SPECIFICATIONS AND STANDARDS

● EQUIPMENT DESIGN STANDARDS

MIL-STD-454: THE KEY DOCUMENT FOR APPROVED PARTS/PROCESS DESCRIPTION
74 REQUIREMENTS: BEARINGS, FASTENERS, ADHESIVES, SEALING...
FURTHER REFERENCES. EXAMPLE - REQ 17 PRINTED WIRING BOARDS
REFERENCES TO MIL-STD-275
MIL-P-55110

MIL-STD-461: ELECTROMAGNETIC EMISSION AND SUSCEPTIBILITY REQUIREMENTS
FOR CONTROL OF EMI

DOD-STD-1788: NEW STANDARD FOR LRUs. INCLUDES THERMAL, STRUCTURAL,
DESIGN METHODS, QUALIFICATION, AND TESTING. PARALLELS
MIL-E-5400 IN MANY AREAS

● EQUIPMENT TEST SPECIFICATIONS AND STANDARDS

MIL-STD-810: A KEY DOCUMENT THAT DESCRIBES TESTING IN 20 ENVIRONMENTAL AREAS

MIL-STD-5422: FOR USE WITH MIL-E-5400. 14 TEST AREAS SIMILAR TO MIL-STD-810

MIL-STD-462: FOR USE WITH MIL-STD-461. EMI TEST PROCEDURES

Figure 3. "Interpretation of DOD Specifications for Device Designers", Marc
Saltzman, Fairchild Communications and Electronics Company. Century
Blvd., Germantown, MD 20874-1182.

COMPARISON OF ENVIRONMENTAL REQUIREMENTS

	USAF MIL-E-5400T	USN MIL-E-16400G	ARMY USAGE MIL-E-11567
Continuous Operating Temperature (°C)	Class 1: −54 to 55 Class 1A: −54 to 55 Class 1B: −40 to 71 Class 3: −54 to 95 Class 4: −54 to 125 Class 5: −54 to 95	Range 1: Exposed and unsheltered (ship or shore) −54 to 65 Range 2: Exposed and unsheltered (ship) −28 to 65 Range 3: Sheltered non-controlled environment (shore) −40 to 50 Range 4: Sheltered controlled environment (ship or shore) 0 to 50 Test to MIL-STD-810, Method 501, Proc. I.	Cold Area −51 to 49 Temperate Area −40 to 52 Desert & Tropics 0 to 71 All Indoor Areas 0 to 52 Reduce high temperature extreme by 1.94°C per 1000 feet above sea level.
Intermittent Operating Temperature (°C)	Class 1: 71 Class 1A: 71 Class 1B: 71 Class 2: 95 Class 4: 125 Class 5: 125 all for 30 minutes	Not Specified.	Not Specified.
Non-Operating/Storage Temperature	Class 1: −57 to 85 Class 1A: −57 to 85 Class 1B: −57 to 85 Class 2: −57 to 95 Class 4: −57 to 150 Class 5: −57 to 125	Range 1: −62 to 71 Range 2: −62 to 71 Range 3: −62 to 71 Range 4: −62 to 71	All Areas −57 to 68
Maximum Temperature Rate of Change	Class 1: −57 to 85 Class 1A: −57 to 85 Class 1B: −57 to 85 Class 2: −57 to 125 Class 4: −57 to 150 Class 5: −57 to 125 at 1°C per second	Four (4) hours from maximum to minimum temperature in each range.	Not Specified.

Figure 4. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

COMPARISON OF ENVIRONMENTAL REQUIREMENTS (CONT'D.)

FAIRCHILD

	USAF MIL-E-5400T	USN MIL-E-16400G	ARMY USAGE MIL-E-4158?
Altitude	Class 1: 0 to 30,000 ft (30 to 3.4 in Hg) Class 1A: 0 to 30,000 ft (30 to 8.88 in Hg) Class 1B: 0 to 15,000 ft (30 to 16.89 in Hg) Class 2: 0 to 70,000 ft (30 to 0.33 in Hg) Class 3: 0 to 100,000 ft (30 to 0.32 in Hg) Class 4: 0 to 100,000 ft (30 to 0.32 in Hg) Class 5: 0 to 200,000 ft (30 to 10⁻¹⁰ in Hg)	Not Specified.	Operating: 0 to 15,000 ft (30 to 16.9 in Hg) Non-Operating: 0 to 40,000 ft (30 to 5.54 in Hg)
Altitude Rate of Change	0.5 in Hg per second.	Not Specified.	Not Specified.
Temperature Altitude Combination	See Figures 1 through 4.	Not Specified.	Not Specified.
Relative Humidity	Up to 100%, condensation on equipment.	Up to 95% including condensation on the equipment.	Minimum: 20% from minimum operating temperature to 16°C. Above 16°C relative humidity based on a dew point of -7°C (100 Figure 5). Maximum: 100% including condensation from the minimum operating temperature to 27°C. Above 27°C the relative humidity based on a dew point of 27°C (100 Figure 5).

Figure 5. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

COMPARISON OF ENVIRONMENTAL REQUIREMENTS (CONT'D.)

Ⅲ FAIRCHILD

	USAF MIL-E-5400T	USN MIL-E-16400	ARMY USAGE MIL-E-01587
Sinusoidal Vibration	Propeller Aircraft: 5 to 500 Hz at the amplitudes shown in Figure 6. Jet Aircraft: 5 to 2000 Hz at the amplitudes shown in Figure 6. Helicopters: 5 to 200 Hz at the amplitudes shown in Figure 7, Curve IIIb.	Type I vibration test per MIL-STD-167-1 for each of the three (3) axes— 4-15 Hz: 0.060 in. double amp 16-25 Hz: 0.040 in. double amp 26-33 Hz: 0.020 in. double amp 34-40 Hz: 0.010 in. double amp 41-50 Hz: 0.006 in. double amp Five (5) minutes at each integral frequency; e.g., 5 min. at 4 Hz, 5 min. at 5 Hz, etc. Endurance test to dwell at resonance for two (2) hours.	Not Specified — Refers to detailed equipment specification.
Random Vibration	Propeller Aircraft: Not Specified. Jet Aircraft: 15 to 2000 Hz at the amplitude specified in the detailed equipment specification or contract.	Not Specified.	Not Specified.
Combined Sinusoidal and Random Vibration	Per the detailed equipment specification.	Not Specified.	Not Specified.
Shock (equipment required to operate afterwards)	15 G's, 11 ± 1 millisecond duration; 3 shocks in + direction and 3 shocks in − direction. Repeat for the remaining axes (total number of shocks = 18).	Grade A, Type A, Class I, shock test per MIL-S-901. MORE: Class I is for equipment that will perform without resilient mountings. Test: For equipment < 250 lbs. a total of 9 hammer blows; 3 blows to each of the principal axes of the equipment using hammer drop heights of 1, 3, and 5 feet respectively. Test equipment specified in MIL-S-901.	Not Specified — Refers to detailed equipment specification.
Shock, Equipment Mounting to Determine Crash Safety (no failure of attachment structure permitted)	30 G's, 11 ± 1 millisecond duration; 2 shocks in + direction and 2 shocks in − direction. Repeat for the remaining axes (total number of shocks = 12).	Not Specified.	Not Specified.

Figure 6. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

OPTICAL DISK DRIVE PACKAGING METHODS

FAIRCHILD

PACKAGING TYPICAL OF EQUIPMENT BAY MOUNTED BOXES

● DESIGN PER DOD-STD-1788 (SIMILAR TO AIR TRANSPORT RACK (ATR) BOXES)

TOP AIR INLET

REAR INTERFACE CONNECTOR

BOTTOM AIR INLET

12.76

AIR OUTLET

FRONT LATCH

POWER SUPPLY ~1.5"

DISK DRIVE COMPARTMENT ~4.5"

2 PWBs SUPPORT ELECTRONICS ~1.5"

7.50 #6 LRU

BOX INCREMENTS ARE 1.30 INCHES

7.64

● PACKAGING TYPICAL OF PANEL MOUNTED BOXES SUCH AS USED IN THE COCKPIT AREA

- ADAPT DRIVE TO FIT IN ENVELOPE DEFINED BY MS25212 -

COOLING AIR LOUVERS

DAGGER PIN INTERFACE

MAY BE REQUIRED

TOP VIEW

HOLE FOR FRONT PANEL FASTENER

QUICK RELEASE FASTENERS
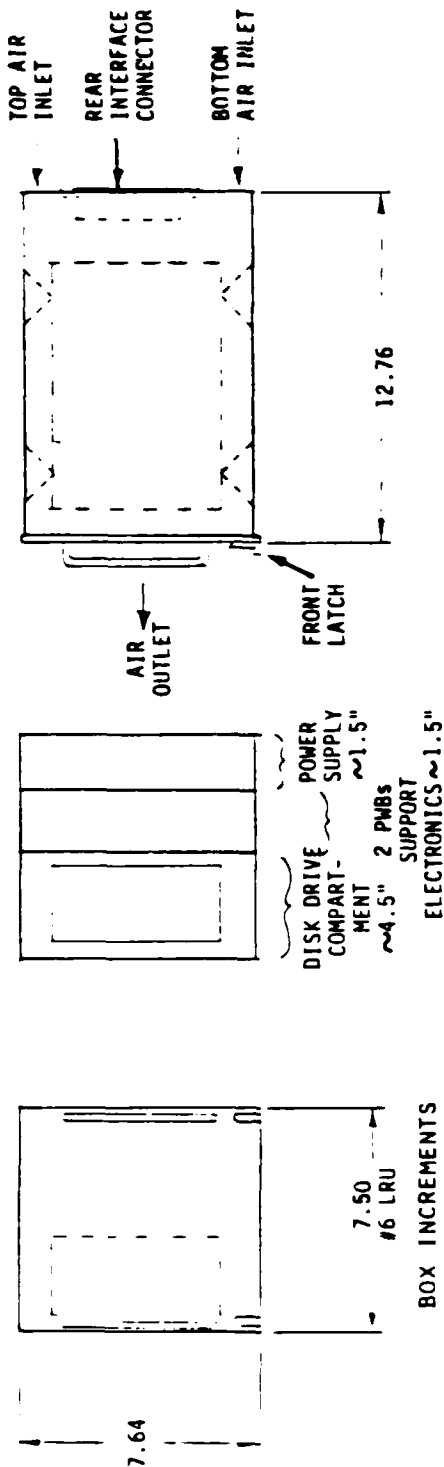
ELECTRONICS ACCESS

MEDIA ACCESS PANEL (SEALED)

Figure 7. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

OMTR/117

TEMPERATURE/ALTITUDE REQUIREMENTS
FOR AIRBORNE ELECTRONICS EQUIPMENT

FAIRCHILD

CLASS 2 EQUIPMENT

CURVE A

CURVE B

CURVE A – DESIGN AND TEST REQUIREMENTS FOR CONTINUOUS OPERATION OF EQUIPMENT DESIGNED TO OPERATE AT 71°C AT SEA LEVEL.

CURVE B – DESIGN AND TEST REQUIREMENTS FOR INTERMITTENT OPERATION OF EQUIPMENT DESIGNED TO OPERATE CONTINUOUSLY AT 71°C AT SEA LEVEL.

ALTITUDE IN FEET

TEMPERATURE°C

- SEVEN TEMPERATURE ALTITUDE CURVES IN MIL-E-5400

- THE CLASS 2 CURVES TO THE RIGHT COVER MOST APPLICATIONS AND ENVELOPE THE REQUIREMENTS FROM MIL-E-4158 AND MIL-E-16400

- CURVES USED TO DETERMINE DRIVE TEMPERATURE IN A FREE CONVECTION ENVIRONMENT
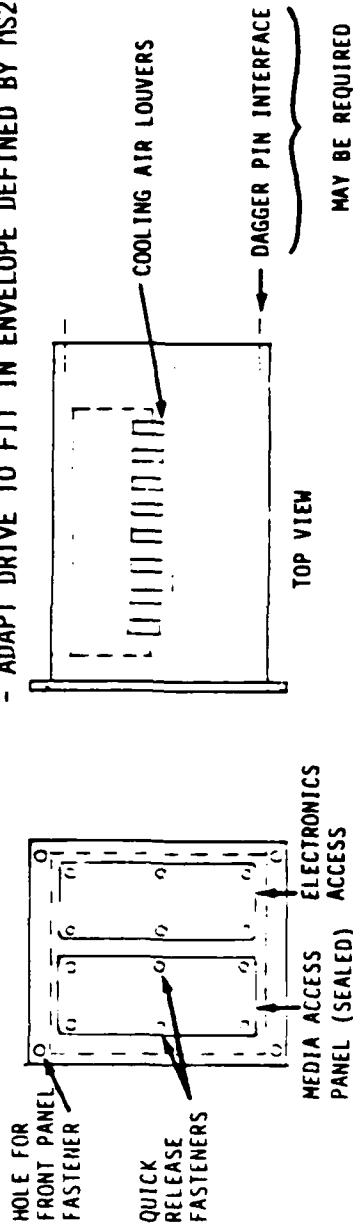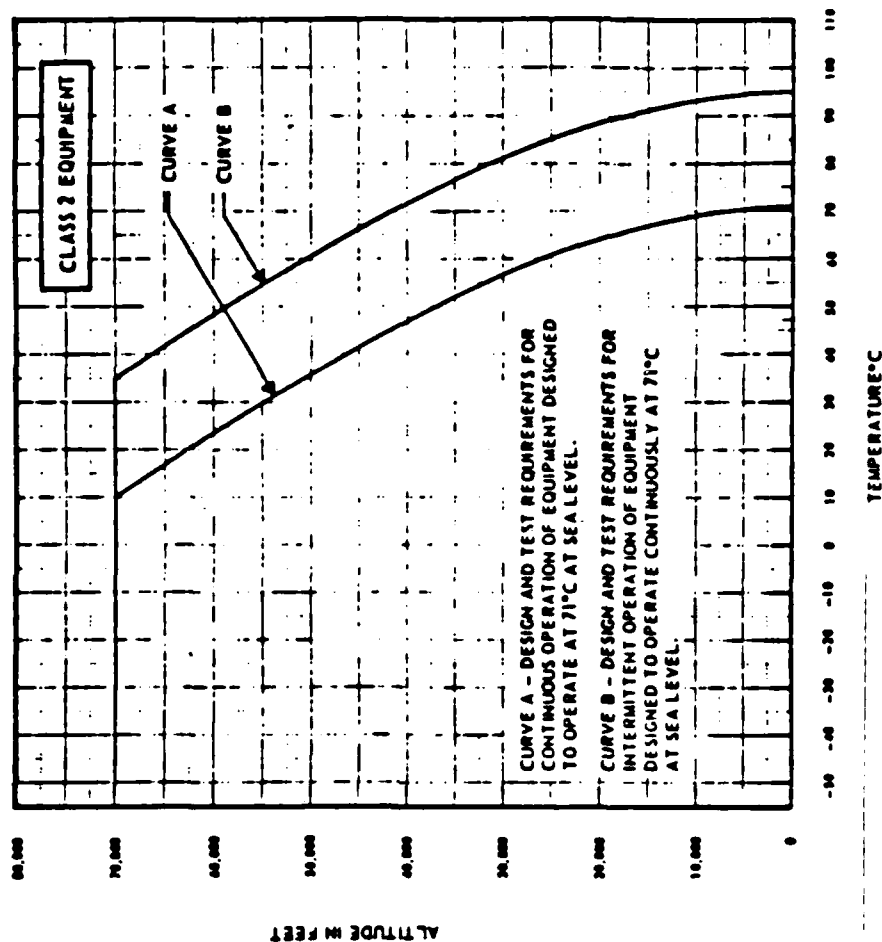
Figure 6. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

118/OMTR

FREE CONVECTION PARAMETRIC ANALYSIS

- THERMAL ANALYSIS INPUTS

  - DRIVE DIMENSIONS
  - FIN STRUCTURE
  - AMBIENT CONDITIONS

- RESULTS

  - SURFACE AREA ENHANCEMENT OR
    OTHER MEANS TO DECREASE DRIVE
    TEMPERATURE ESSENTIAL
  - DESIGNERS MUST CONSIDER EFFECT
    OF ALTITUDE
  - DRIVES OPERATED IN FREE
    CONVECTION ENVIRONMENTS MUST
    DISSIPATE MINIMAL ENERGY
  - 10 WATT DRIVE → ΔTs OVER AMBIENT
    OF 20°C OR LESS
  - 20 WATT DRIVE → ΔTs OVER AMBIENT
    OF 40°C OR LESS
  - DRIVE INTERNAL TEMPERATURES WOULD
    BE 5 TO 10°C HIGHER AND WELL OVER
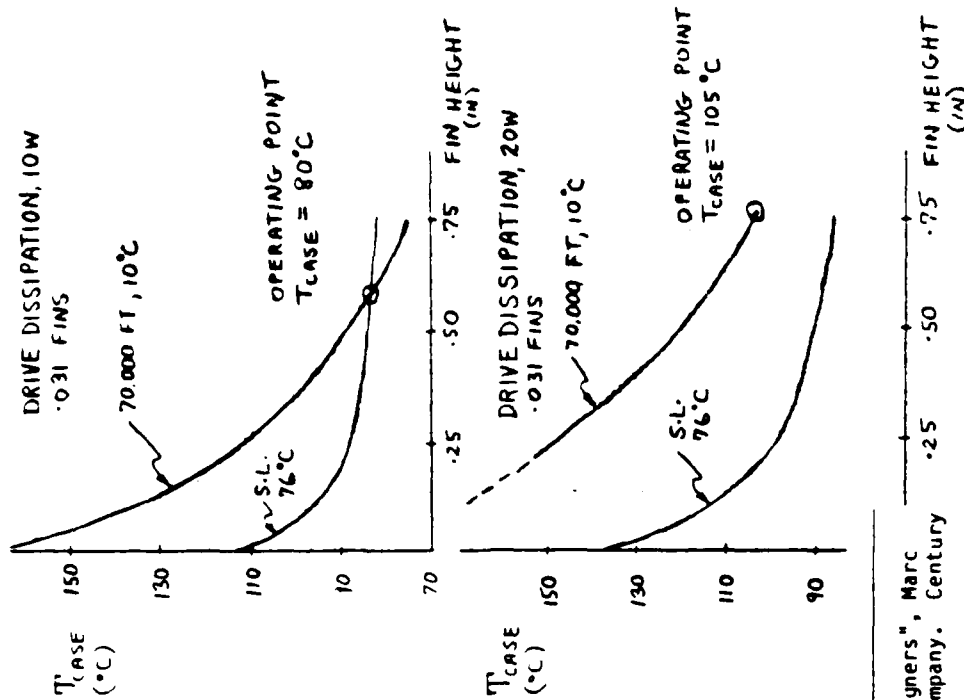   PRESENT DAY MEDIA CAPABILITIES

Figure 9. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

OMTR/119

COOLING AIR MASS FLOW RATE
AS PROVIDED IN DOD-STD-1788

FAIRCHILD

USE IN RELATION BELOW TO
DETERMINE EXIT AIR TEMPERATURE

$$T_{OUT} = T_{IN} + \dfrac{Q \longleftarrow \text{POWER DISSIPATION}}{\dot{M}C_P \longrightarrow .24}$$

FROM GRAPH

T_{OUT} REPRESENTS A THERMODYNAMIC
LOWER LIMIT FOR THE DRIVE CASE
TEMPERATURE
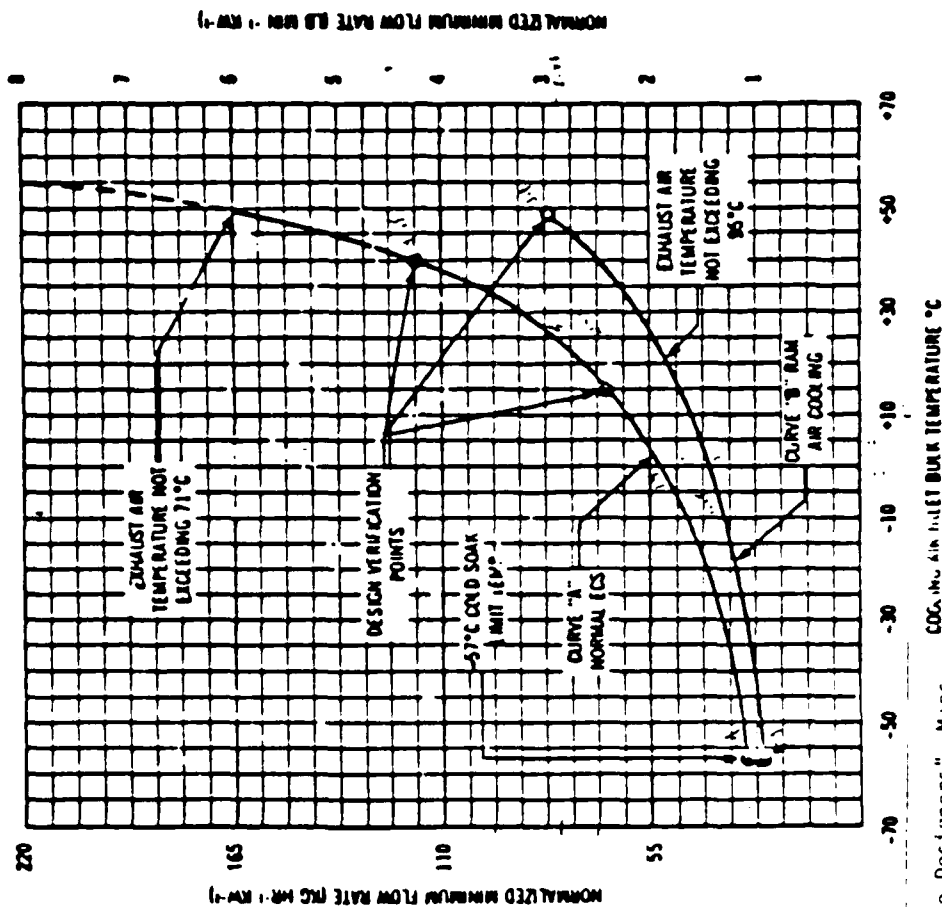
Figure 10.

"Interpretation of DOD Specifications for Device Designers", Marc
Saltzman, Fairchild Communications and Electronics Company. Century
Bl d., Germantown, MD 20874-1182.

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Figure 11. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

SINUSOIDAL VIBRATION REQUIREMENTS FOR EQUIPMENT DESIGNED
FOR INSTALLATION IN PROPELLER AIRCRAFT (5-500 Hz)
AND JET AIRCRAFT (5-2000 Hz)

⊞ FAIRCHILD

- CURVE 111A FROM MIL-E-5400, FOR USE WITH EQUIPMENT MOUNTED IN THE FORWARD HALF OF THE FUSELAGE OR IN THE WING AREA WITH THE ENGINES AT THE REAR OF THE FUSELAGE

- CURVE 111A COVERS MOST SITUATIONS FOR OPTICAL DISK DRIVE USAGE

- USE THE CURVE WITH THE ISOLATION CHARACTERISTICS TO DETERMINE THE SINUSOIDAL VIBRATION PROFILE SEEN BY THE DRIVE

Figure 12. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

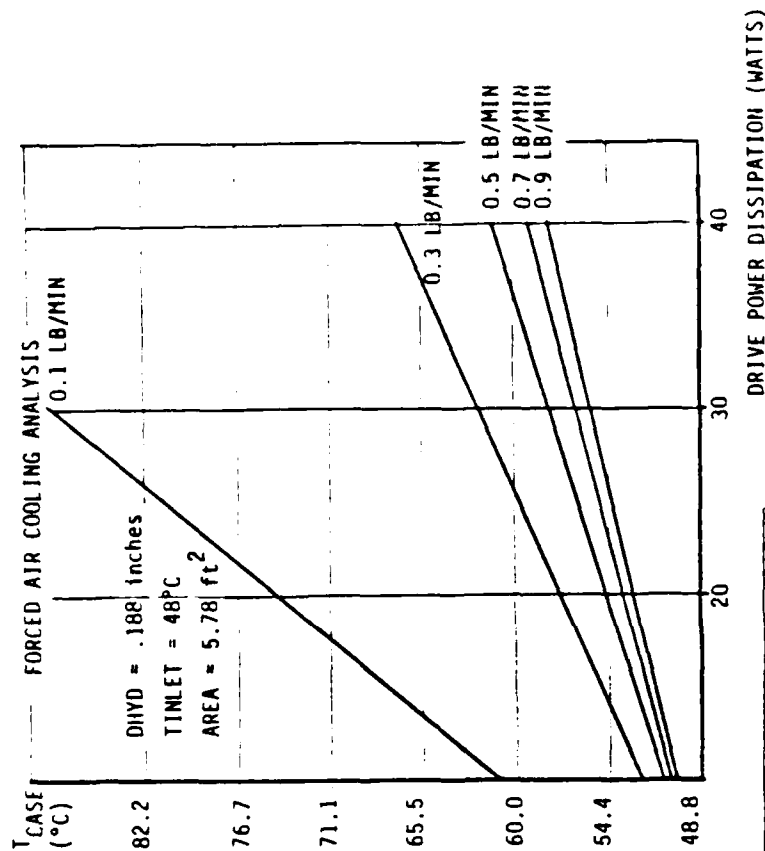122/OMTR

Figure 13. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

SINUSOIDAL VIBRATION LEVELS

SEEN BY THE DRIVE

FAIRCHILD

- ASSUMES COMMERCIALLY AVAILABLE ISOLATORS "FILTERING" CURVE IIIA MILITARY INPUT.

- CAN BE CONVERTED TO G LOADING BY RELATION INDICATED ON GRAPH.

- RESULTS:

  - MAXIMUM D.A. OF
    0.20 AT 13 Hz

  - MAXIMUM G's OF
    2.72 AT 23 Hz

  - AT 1800 RPM =
    30 Hz
    D.A. = .055 INCH
    G's = 2.52 G's

  - AT 3000 RPM =
    50 Hz
    D.A. = .009 INCH
    G's = 1.148 G's

COMPOSITE RANDOM VIBRATION REQUIREMENTS FOR ALL VEHICLES
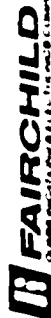
FAIRCHILD

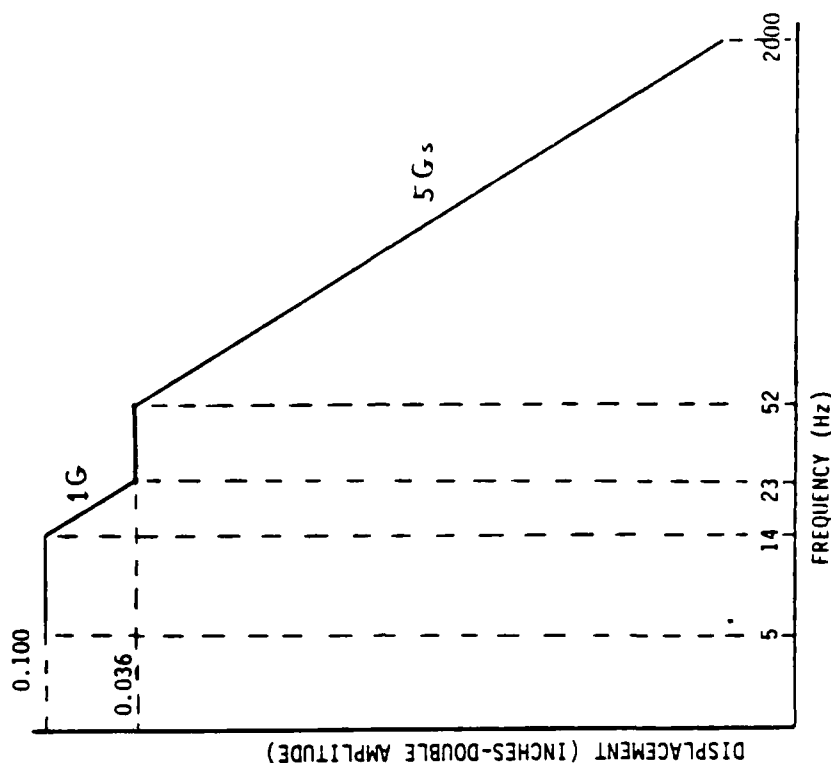- SOURCES: SYSTEMATIC REDUCTION OF INFORMATION FROM MIL-STD-810, POST PROCUREMENT DOCUMENTS
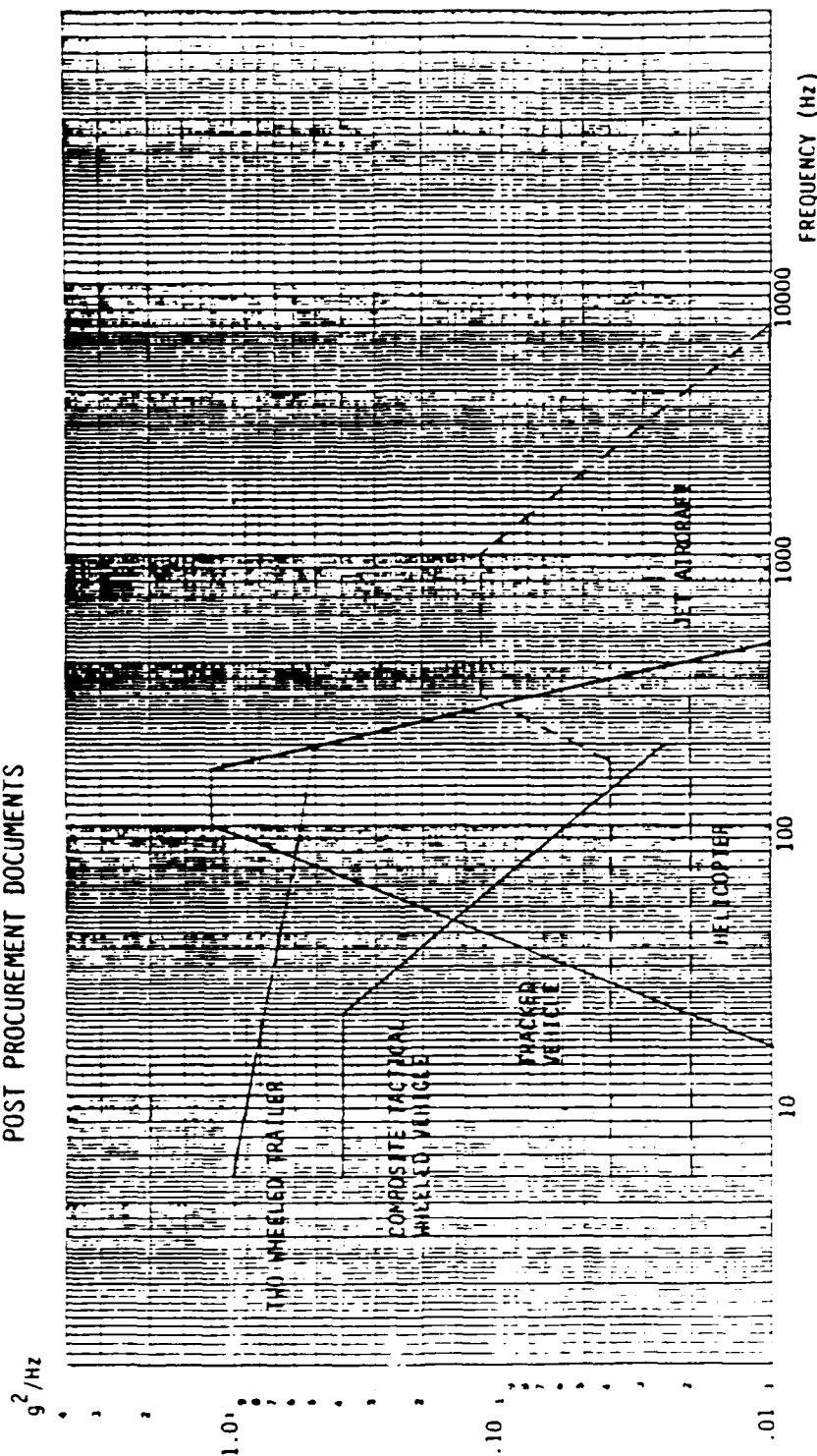
Figure 14. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.
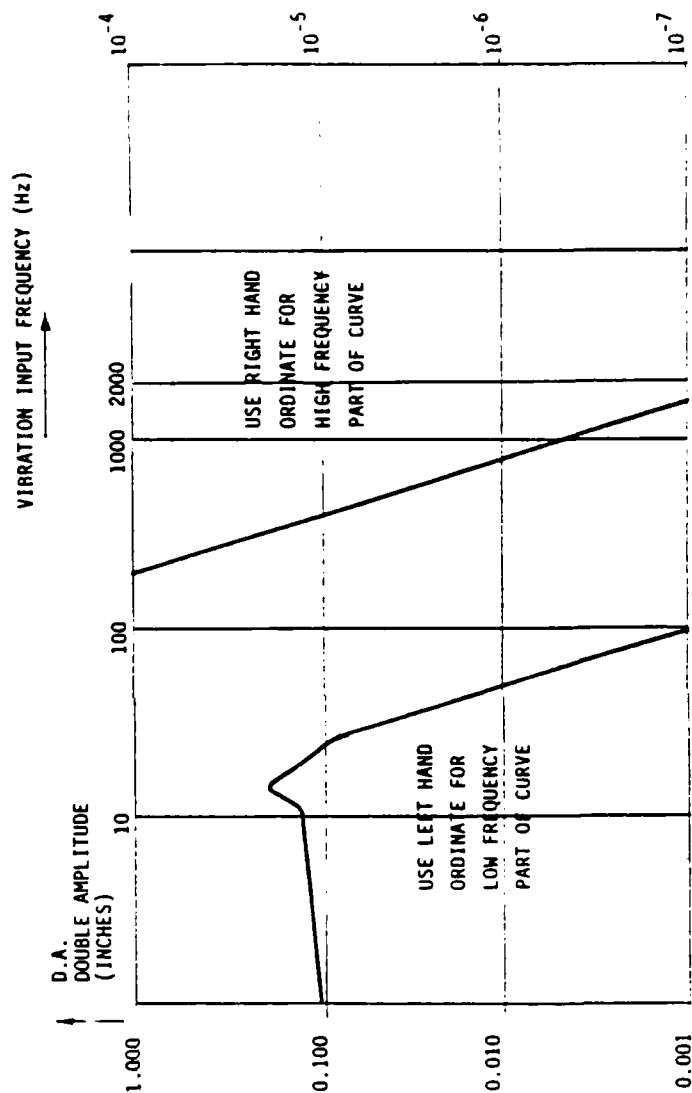
124/OMTR

FAIRCHILD

RANDOM VIBRATION LEVELS

SEEN BY THE DRIVE
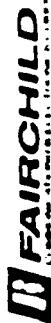
- DOTTED PORTION OF CURVE REPRESENTS TRANSPORTATION TYPE LEVELS AFTER FILTERING BY ISOLATION SYSTEM.

- SOLID PORTION OF CURVE REPRESENTS JET AIRCRAFT LEVELS AFTER FILTERING.

- JET AIRCRAFT LEVELS BECOME DOMINATE AT 300 Hz.

- RESULTS:

FROM THE VIBRATION STANDPOINT, TRANSPORTATION LEVELS AT LOW FREQUENCY MAY REPRESENT A GREATER PROBLEM THAN IN A HIGH PERFORMANCE AIRCRAFT.

POWER SPECTRAL DENSITY (G^2/Hz)

FREQUENCY (Hz)

USE RIGHT HAND ORDINATE

USE LEFT HAND ORDINATE

DASHED LINE = ALL TRANSPORT METHODS

SOLID LINE = JET AIRCRAFT

1.00   0.10   0.01

0.001   0.0001   0.00001

10   100   500

II FAIRCHILD
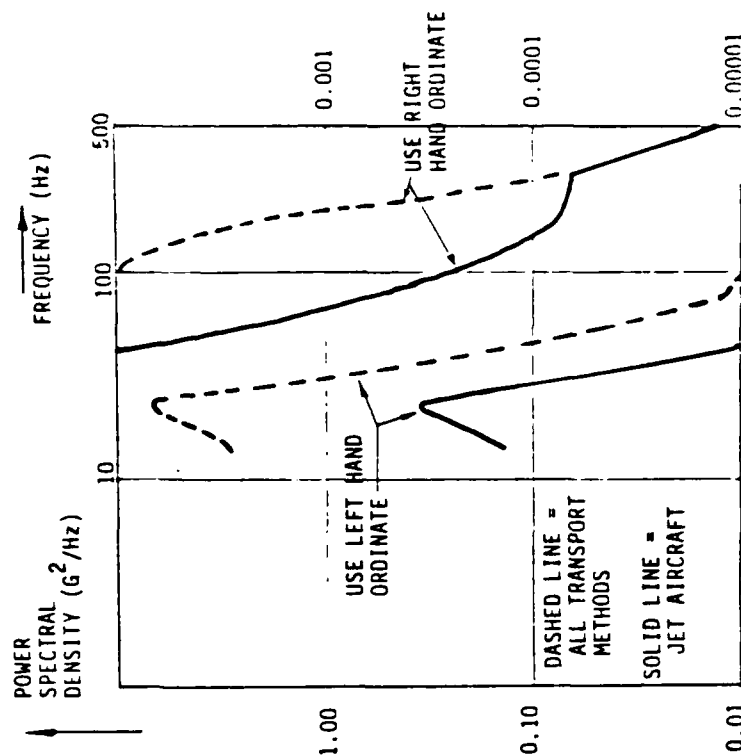
SUMMARY OF OPTICAL DISK DRIVE

ENVIRONMENTAL REQUIREMENTS

DRIVE REQUIREMENTS

- CONTINUOUS OPERATING TEMPERATURE (AMBIENT AIR)

  CONVECTIVELY COOLED DRIVE — -54 TO 76°C

  FORCED AIR COOLED DRIVE — -54 TO 43°C[1]

- MINIMUM AND MAXIMUM STORAGE TEMPERATURE — -62 TO 95°C

- ALTITUDE AND ALTITUDE RATE OF CHANGE — S.L. TO 70,000 FEET
  ± 0.49 PSI/SEC

- MAXIMUM RELATIVE HUMIDITY — 100% WITH CONDENSATION [2]
  AND FROSTING

- SINUSOIDAL VIBRATION INPUT TO DRIVE — PER GRAPH

- RANDOM VIBRATION INPUT TO DRIVE — PER GRAPH

- SHOCK: CONTINUOUS OPERATION — 3.0 G PEAK, 11 MSEC
  1/2 SINE PULSE

  OPERATE AFTER — 12 G PEAK

  STRUCTURAL INTEGRITY — 40 G PEAK

- STEADY STATE ACCELERATION:

  CONTINUOUS OPERATION — 7.5 G's

  OPERATE AFTER — 11.3 G's

  STRUCTURAL INTEGRITY — 17.0 G's

NOTES

1. REQUIRES ADDITIONAL AIRFLOW

2. REQUIRES PACKAGING PROTECTION VIA FULL OR PARTIAL SEALING AND AIR DRYING/FILTRATION

Figure 16. "Interpretation of DOD Specifications for Device Designers", Marc Saltzman, Fairchild Communications and Electronics Company. Century Blvd., Germantown, MD 20874-1182.

OPTICAL MEMORY SYSTEM STUDY PRESENTATION

PREPARED FOR:

NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA

BY:

FAIRCHILD COMMUNICATIONS & ELECTRONICS COMPANY
GERMANTOWN, MD

CONTRACT # G229-86C-0424

5 DECEMBER 85

UNDER DIRECTION OF ROMAN FEDORAK

Figure 1. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OPTICAL MEMORY STUDY TEAM

FAIRCHILD
COMMUNICATIONS & ELECTRONICS COMPANY

3M Company

CHEROKEE DATA SYSTEMS

Figure 2. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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OPTICAL MEMORY SYSTEM REPORT PREPARED BY

FAIRCHILD - P. JAMES, M. SALTZMAN, T. ROGERS

3M COMPANY - C. HARRISON, F. WHITEHEAD, R. MILLER

CHEROKEE DATA SYSTEMS - W. HALL, M. DEESE

Figure 3. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OPTICAL MEMORY SYSTEM PROJECT STATEMENTS

▪ PROBLEM

- EXTREMELY LARGE CAPACITY OF DATA STORAGE REQUIRED TO
  ACHIEVE NEAR TERM MILITARY SYSTEM PERFORMANCE OBJECTIVES

▪ OBJECTIVE

- EXPLOIT CURRENT AND NEAR FUTURE OPTICAL DISK TECHNOLOGY
  FOR RELEVANCY TO A SOLUTION FOR A MILITARY MASS MEMORY
  (OMS) THAT SATISFIES MILITARY APPLICATIONS

▪ PRODUCT

- HIGH LEVEL DESIGN OF MILITARY PERFORMANCE OMS

- DEVELOPMENT PLAN

FAIRCHILD

Figure 4. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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FAIRCHILD

APPLIED OBJECTIVES
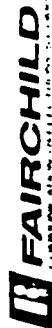
- INVESTIGATE 5 1/4" OPTICAL DISK TECHNOLOGY

- CONSIDER MILITARY SPECIFICATIONS, APPLICATIONS, AND PERFORMANCE REQUIREMENTS

- PERFORMANCE - CAPACITY - 250 MBYTES

  ACCESS - 100 MSEC

  TRANSFER - 5 MB/SEC

- CONCENTRATE ON KEY ELEMENTS

Figure 5. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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STUDY OUTLINE
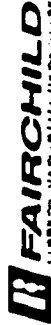
I   EXPLORE STATE OF OPTICAL MEMORY SYSTEM TECHNOLOGY

II   DEVELOP SYSTEM REQUIREMENTS

III   INVESTIGATE FEASIBILITY OF A COMMON WORM, EROM DRIVE

IVA   MEDIA EVALUATION

IVB   OPTICAL HEAD EVALUATION

IVC   DRIVE EVALUATION

IVD   SYSTEM SUPPORT ELEMENTS EVALUATION

V   TOP LEVEL SYSTEM DESIGN/SPECIFICATION

VI   DEVELOPMENT PLAN

VII   NUCLEAR RADIATION ANALYSIS/TESTING

VIII ARCHITECTURE INVESTIGATION

<u>Figure 6.</u> "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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ENVIRONMENTAL REQUIREMENTS

Figure 7.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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ENVIRONMENTAL MILITARY REQUIREMENTS

FAIRCHILD

USAF	USN	USA
MIL-E-5400T	MIL-E-16400	MIL-E-4158

TRANSLATE EXTERNAL ENVIRONMENT SPECIFICATIONS TO LOCAL DISK DRIVE

ENVIRONMENT DEVELOP

" DESIGN TO" REQUIREMENTS

Figure 8. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

FAIRCHILD

OPERATIONAL REQUIREMENTS
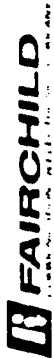
- ENVIRONMENT

- NUCLEAR RADIATION/EMP

- SIZE, WEIGHT, POWER

- FORM FACTOR

- RELIABILITY

- MAINTAINABILITY

- BIT/SELF-TEST

Figure 9. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FUNCTIONAL REQUIREMENTS

FAIRCHILD

- CAPACITY   - INTERFACE

- ACCESS TIMES   - INTERCHANGEABILITY

- TRANSFER RATES   - TRANSPORTABILITY

- OPERATING MODES   - LIFE

- FILE MANAGEMENT   - OTHER CHARACTERISTICS

- ERROR RATE

Figure 10. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
            Communications and Electronics, 20301 Century Boulevard, Germantown,
            MD 20874-1182.

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TABLE 2.3   Environmental System Requirements Taken From Principal Military Specifications

	USAF MIL-E-5400T		USN MIL-E-16400G		ARMY USAGE MIL-E-4158F	
Continuous Operating Temperature (°C)	Class 1: Class 1A: Class 1B: Class 2: Class 3: Class 4: Class 5:	-54 to 55 -54 to 55 -40 to 55 -54 to 71 -54 to 95 -54 to 125 -54 to 95	Range 1: Exposed and unsheltered (ship or shore) Range 2: Exposed and unsheltered (ship) Range 3: Sheltered non-controlled environment (shore) Range 4: Sheltered controlled environment (ship or shore) Test to MIL-STD-810, Method 501, Proc. I.	-54 to 65 -28 to 65 -40 to 50 0 to 50	Cold Area Temperate Area Desert & Tropics All Indoor Areas Reduce high temperature extreme by 1.944°C per 1000 feet above sea level.	-51 to 49 -40 to 52 8 to 71 0 to 52
Intermittent Operating Temperature (°C)	Class 1: Class 1A: Class 1B: Class 2: Class 3: Class 4: Class 5:	71 71 71 95 125 150 125 all for 30 minutes	Not Specified.		Not Specified.	
Non-Operating/Storage Temperature	Class 1: Class 1A: Class 1B: Class 2: Class 3: Class 4: Class 5:	-57 to 85 -57 to 85 -57 to 85 -57 to 95 -57 to 125 -57 to 150 -57 to 125	Range 1: Range 2: Range 3: Range 4:	-62 to 71 -62 to 71 -62 to 71 -62 to 71	All Areas	-57 to 68
Maximum Temperature Rate of Change	Class 1: Class 1A: Class 1B: Class 2: Class 3: Class 4: Class 5:	-57 to 85 -57 to 85 -57 to 85 -57 to 95 -57 to 125 -57 to 150 -57 to 125 at 1°C per second	Four (4) hours from maximum to minimum temperature in each range.		Not Specified.	

Figure 11.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

SUSTAINED ACCELERATION LEVELS FOR JET AIRCRAFT

FAIRCHILD

	FORE	AFT	UP	DOWN	LATERAL
MIL-STD-810 OPERATIONS	2.0	6.0	9.0	3.0	4.0
DOD-STD-1788 OPERATIONS	7.5	7.5	11.3	6.0	6.1
MIL-STD-810 STRUCTURAL INTEGRITY	3.0	9.0	13.5	4.5	6.0
DOD-STD-1788 STRUCTURAL INTEGRITY	11.25	11.25	17.0	9.0	9.15

NOTES:

1. MIL-STD-810 levels are for fuselage locations near the aircraft center of gravity. Refer to the standard for additional yaw, pitch, and roll accelerations away from he CG.

2. Multiply the MIL-STD-810 levels by 2 for catapult launched aircraft.

Figure 12. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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COMPOSITE RANDOM VIBRATION REQUIREMENTS FOR ALL VEHICLES
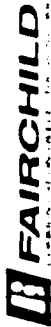
FAIRCHILD

- SOURCES: SYSTEMATIC REDUCTION OF INFORMATION FROM MIL-STD-810, PAST PROCUREMENT DOCUMENTS

Figure 13. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

SINUSOIDAL VIBRATION INPUT TO DRIVE (AFTER ISOLATION)

Figure 14. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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SUSTAINED ACCELERATION LEVELS FOR JET AIRCRAFT

FAIRCHILD

	FORE	AFT	UP	DOWN	LATERAL
MIL-STD-810 OPERATIONS	2.0	6.0	9.0	3.0	4.0
DOD-STD-1788 OPERATIONS	7.5	7.5	11.3	6.0	6.1
MIL-STD-810 STRUCTURAL INTEGRITY	3.0	9.0	13.5	4.5	6.0
DOD-STD-1788 STRUCTURAL INTEGRITY	11.25	11.25	17.0	9.0	9.15

NOTES:

1. MIL-STD-810 levels are for fuselage locations near the aircraft center of gravity. Refer to the standard for additional yaw, pitch, and roll accelerations away from he CG.

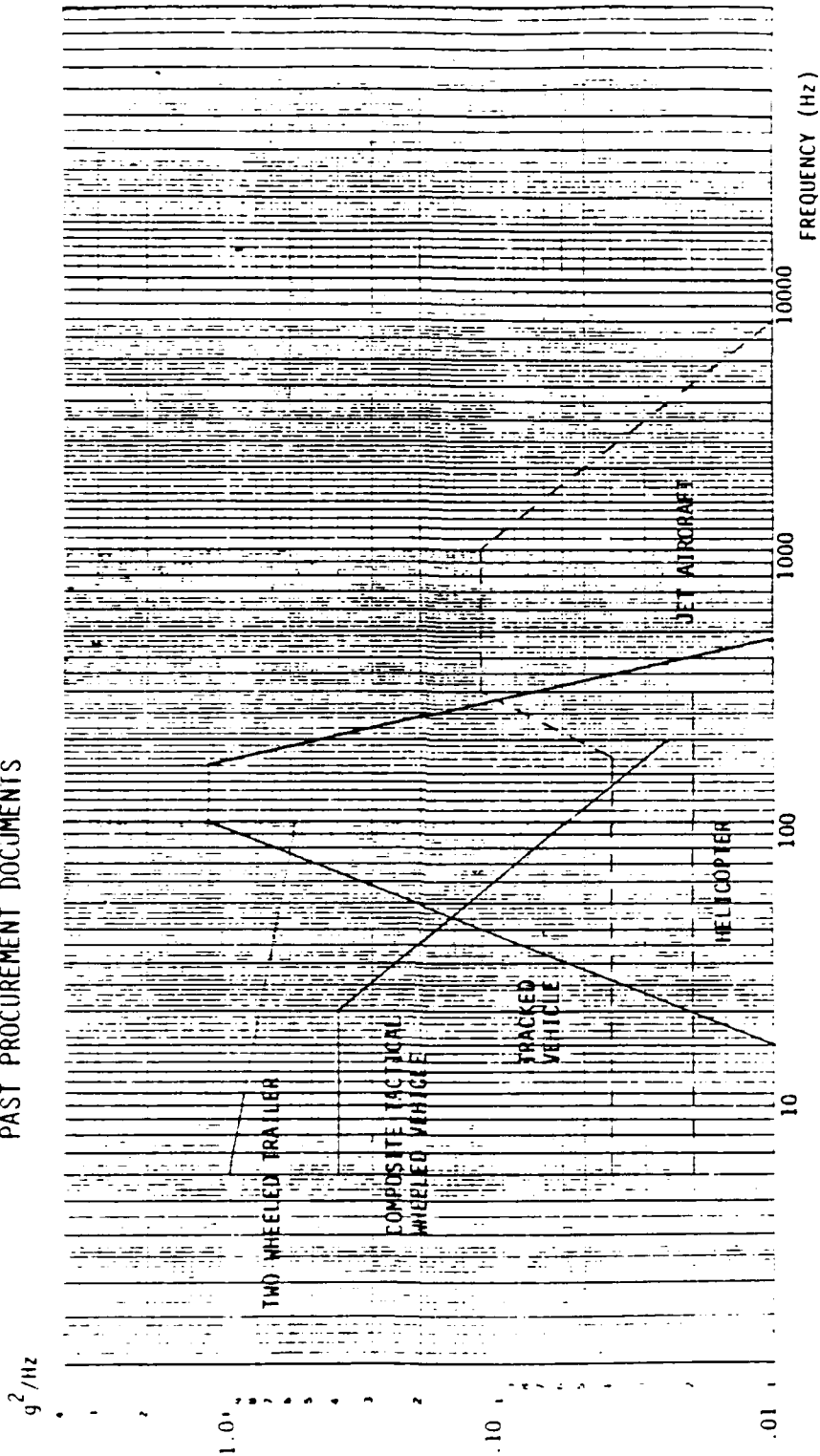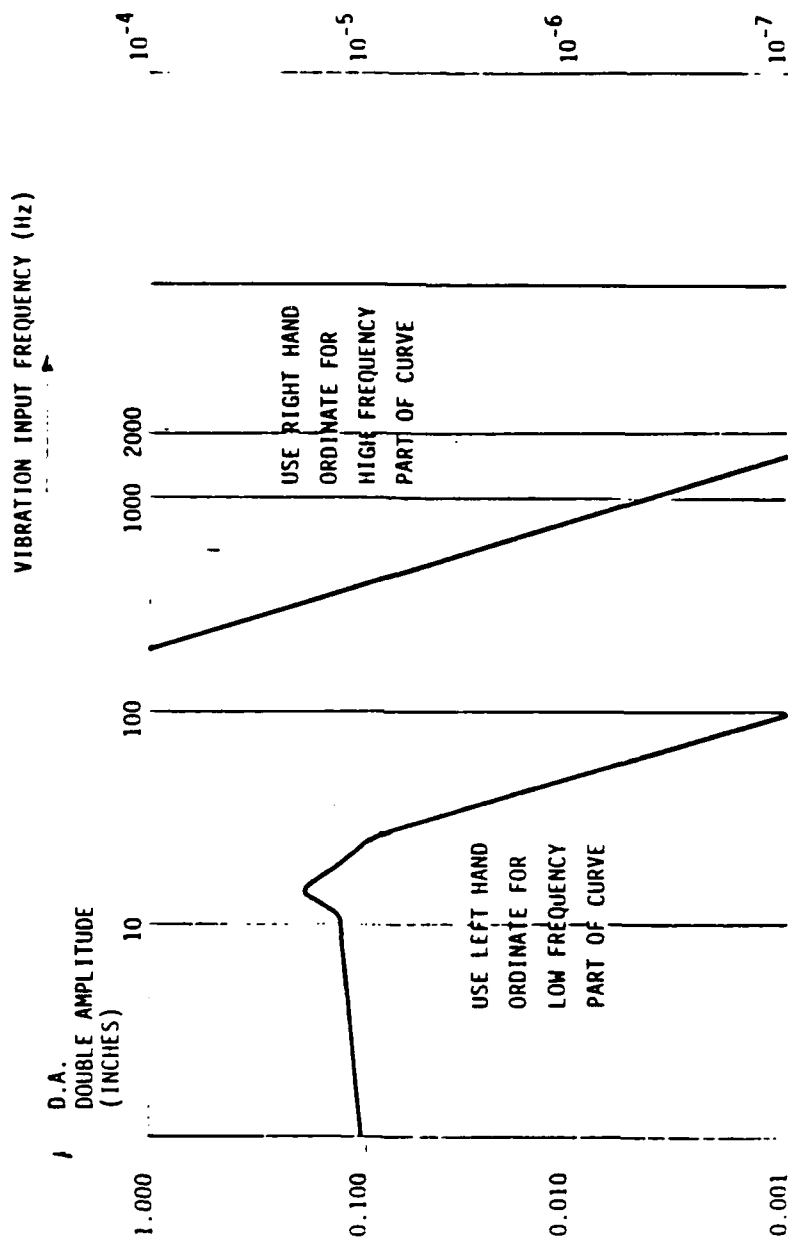2. Multiply the MIL-STD-810 levels by 2 for catapult launched aircraft.

Figure 15. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

SUMMARY OF OPTICAL DISK DRIVE ENVIRONMENTAL
REQUIREMENTS
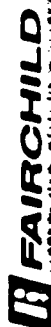
[!] FAIRCHILD

DRIVE REQUIREMENTS

● CONTINUOUS OPERATING TEMPERATURE (AMBIENT AIR)
  - CONVECTIVELY COOLED DRIVE   -54 TO 76°C [1]
  - FORCED AIR COOLED DRIVE   -54 TO 43°C
● MINIMUM AND MAXIMUM STORAGE TEMPERATURE   -62 TO 95°C
● ALTITUDE AND ALTITUDE RATE OF CHANGE   S.L. TO 70,000 FEET
                                                          ±0.49 PSI/SEC
● MAXIMUM RELATIVE HUMIDITY   100% WITH CONDENSATION [2]
                                                          AND FROSTING
● SINUSOIDAL VIBRATION INPUT TO DRIVE   PER GRAPH
● RANDOM VIBRATION INPUT TO DRIVE   PER GRAPH
● SHOCK: CONTINUOUS OPERATION   3.0G PEAK, 11 MSEC
                                                          1/2 SINE PULSE
      OPERATE AFTER   12G PEAK
      STRUCTURAL INTEGRITY   40G PEAK
● STEADY STATE ACCELERATION:
  - CONTINUOUS OPERATION   7.5Gs
  - OPERATE AFTER   11.3Gs
  - STRUCTURAL INTEGRITY   17.0Gs

NOTES: 1/ REQUIRES ADDITIONAL AIRFLOW.
       2/ REQUIRES PACKAGING PROTECTION VIA FULL OR PARTIAL SEALING AND AIR
          DRYING/FILTRATION.

Figure 16. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
            Communications and Electronics, 20301 Century Boulevard, Germantown,
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ADM OPTICAL DISK PERFORMANCE PARAMETERS

FAIRCHILD

GOALS OF STUDY

TECHNOLOGY - 5 1/4" WRITE ONCE MEDIA AND DRIVE
- SINGLE HEAD SYSTEM

CAPACITY - 300 MEGABYTES OF USER DATA (APPLICATION DOES NOT REQUIRE DUAL SIDED MEDIA)

PEAK TRANSFER RATE - 10 MEGABITS/SECOND

DISK CONFIGURATION - CAV SYSTEM

RPM - 2900 REVS PER MINUTE

LATENCY - 20 MILLISECONDS

AVERAGE ACCESS TIME - 80 MILLISECONDS

TRACK TO TRACK ACCESS - 1 MILLISECOND IN FINE SEEK ACCESS

SIZE - 9" LONG X 6" WIDE X 3.75" HIGH

WEIGHT - 5 POUNDS

POWER - 40 WATTS

NADC OBJECTIVES

CAPACITY - 250 MEGABYTES OF USER DATA

PEAK TRANSFER RATE - 5 MEGABITS/SECOND

ACCESS TIME - 100 MILLISECONDS MAXIMUM

Figure 17. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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THEORETICAL LIMITS

Figure 18. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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Figure 19. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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OPTICAL DISK DRIVE DIAGRAM

Figure 20. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OPTICAL DISK GEOMETRY

RECORDING GEOMETRY

Figure 21. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
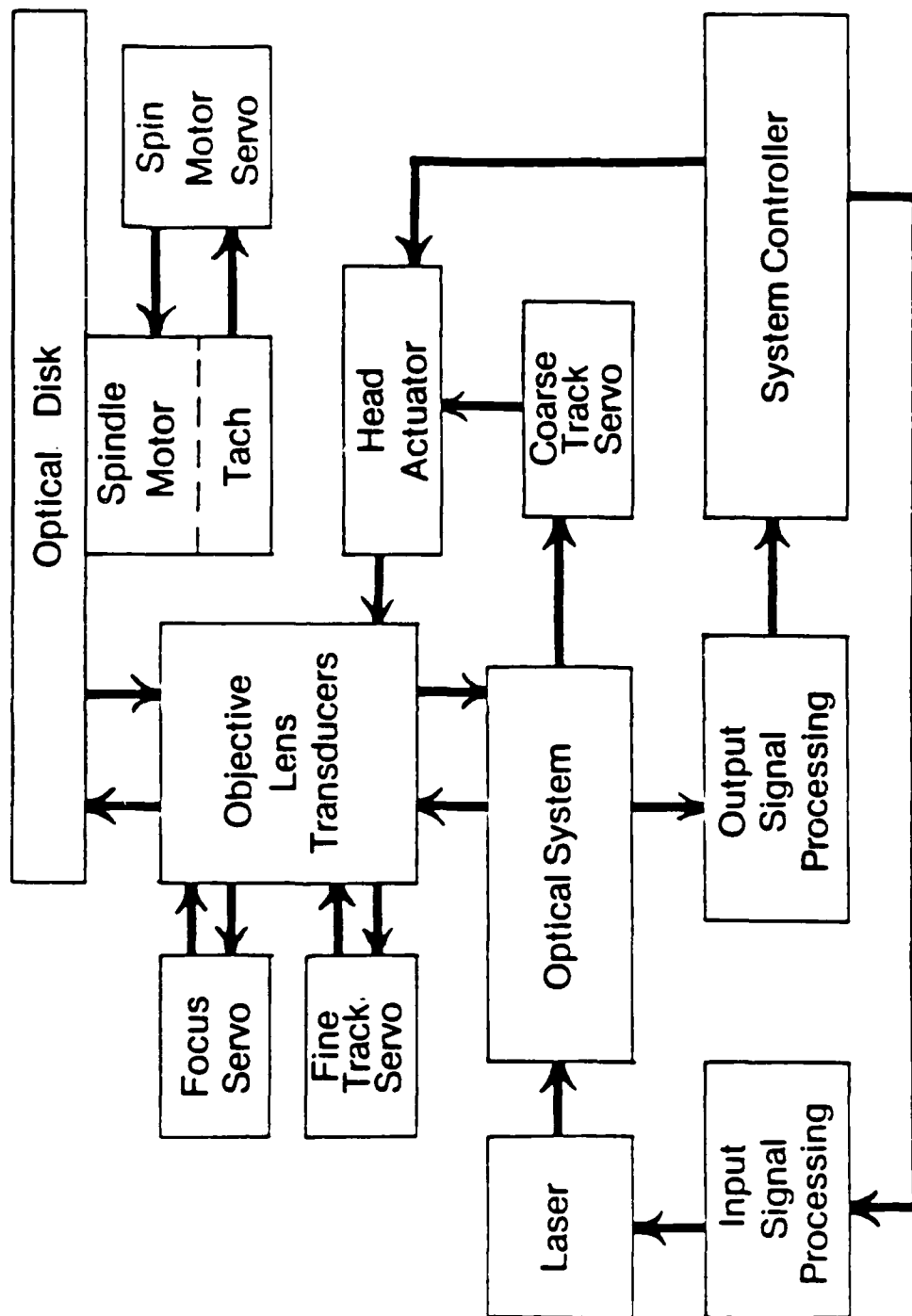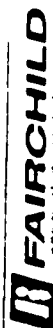
LASER SPOT FORMATION
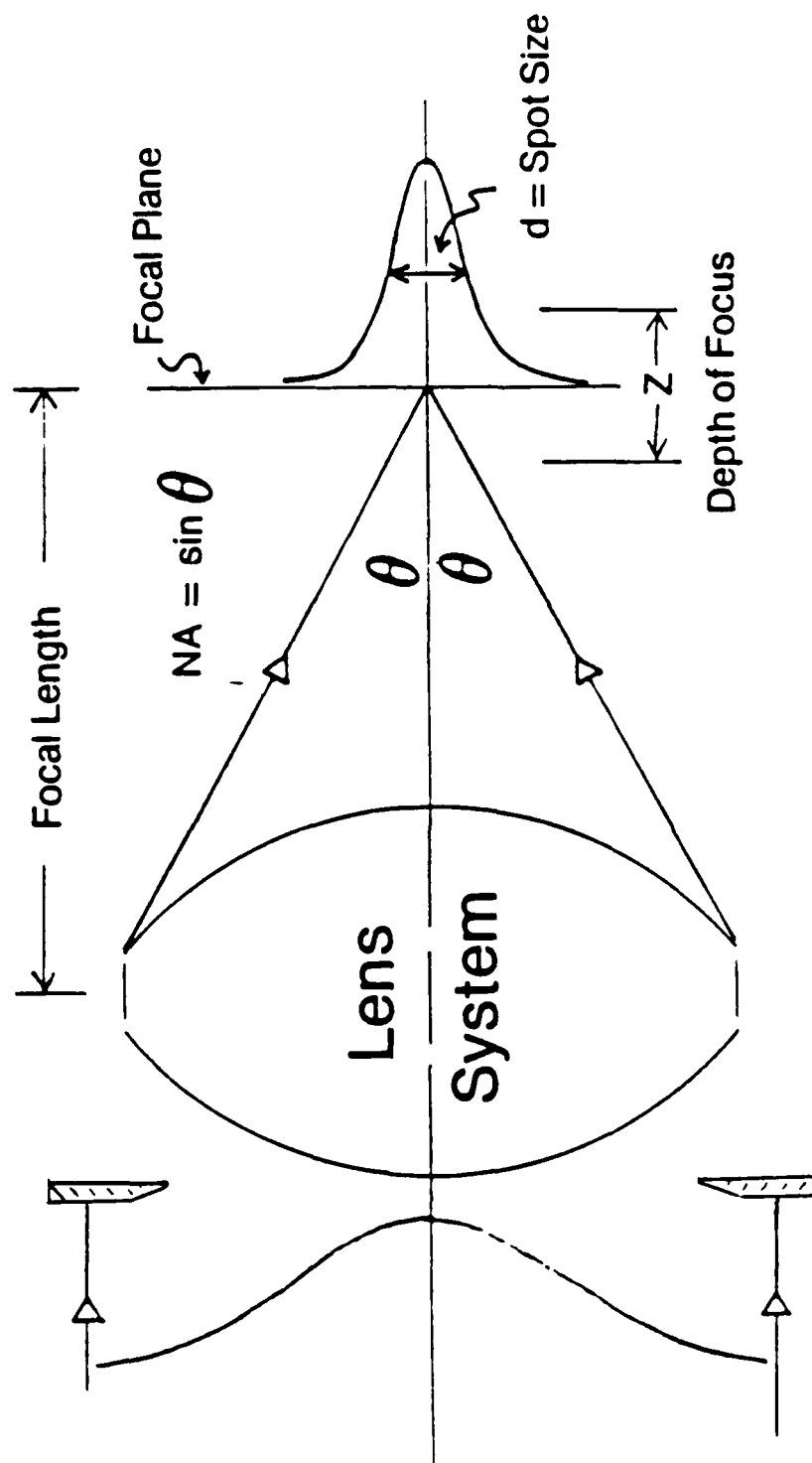
Figure 22. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

THEORETICAL SYSTEM PERFORMANCE

THEORETICAL PERFORMANCE - CAV RECORDING   CAPACITY = 400 MB.

λ = 830 NM.
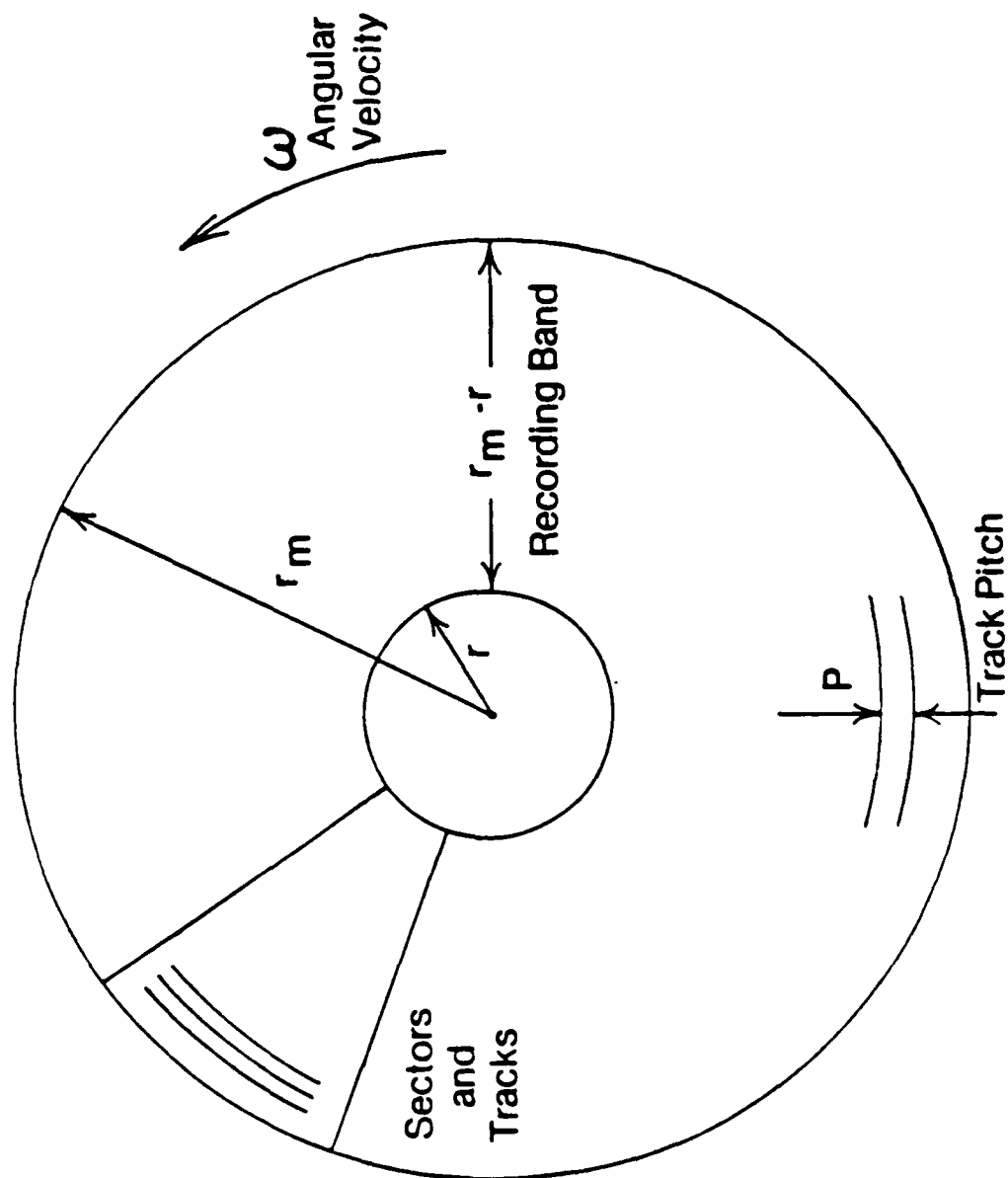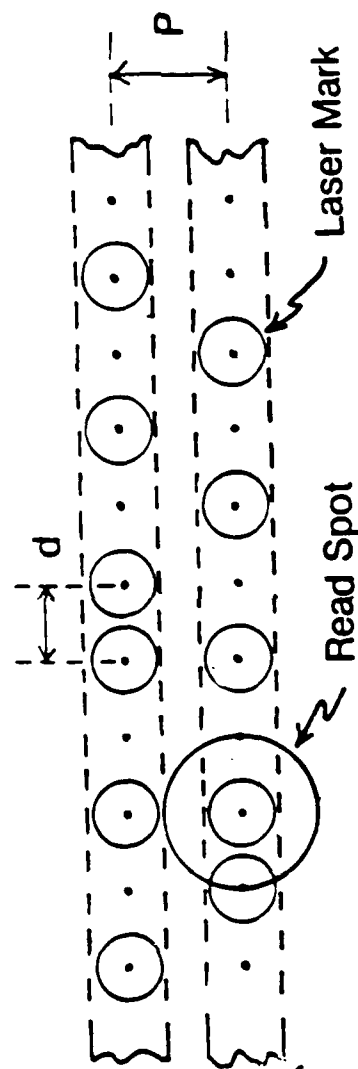
d = 0.6 UM   RATE   = 13.6 MBPS.

Figure 23.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

■ FAIRCHILD

THEORETICAL LIMITATIONS
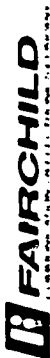
FOCAL SPOT QUALITY

STREHL INTENSITY - $\frac{\text{ACTUAL PEAK INTENSITY}}{\text{THEORETICAL PEAK INTENSITY}}$

FOR SI > .8 SYSTEM IS DIFFRACTION LIMITED

FIGURE IS REDUCED BY ANY PRACTICAL PHENOMENA

- OPTICAL WAVEFRONT DISTORTION

- FOCUS ERROR

- SUBSTRATE THICKNESS

- OPTICAL ALIGNMENT

OPTICAL TOLERANCES/ERROR CONTRIBUORS

- TILT BIREFRINGENCE

- MEDIA FLATNESS, THICKNESS

MAX ERROR OF FOCUS FROM OLD SOURCES AT NA = 0.6, λ = 830 MM

BECOMES 2 = 1.15 μM

VERITCAL CONTROL MUST WORK OVER 100-200 μM RANGE

Figure 24. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

PRACTICAL LIMITATIONS
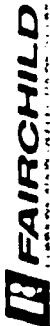
FAIRCHILD

PRACTICAL LIMITATIONS

- POWER, WAVE LENGTH

- TRACKING, FOCUS

- DEFECTS, NOISE, CONTRAST, SNR

- ENCODING, EDAC

- ENVIRONMENT

Figure 25. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

PRACTICAL SPECIFICATIONS
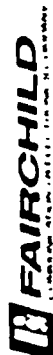
RPM = 3000 - 2000

f OF LASER PWR, SERVO BW, MECHANICAL BALANCE

DATA TRANSFER RATE - 10 MB/S - 5 MB/S

f OF ABOVE + 1.5 μM PIT SPACING, NA = 0.6

CODE OFF = 1.5 (SPACE MODULATION)

B.E.R. = 1×10^{-5} INITIAL, 1×10^{-4} END OF LIFE

N.A. = 0.55 - 0.6, 0.6 INCREASED REQUIREMENT ON MEDIA
AND SERVO SYSTEM

TRACKING SIGNAL VARIATIONS - <10%

NA > 0.55

DATA DENSITY - f OF NA, SIGNAL AMPLITUDE (MTF) DETECTION
TRACK PITCH (50% RESPONSE CURVE OCCURS AT MARK TO MARK
SPACING OF $\sim$ 1.5 μM

Figure 26. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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PRACTICAL SPECIFICATIONS (CONTINUED)

CAPACITY

    250 M BYTES

WRITE THRESHOLD - AT 8 M/SEC

    THRESHOLD = 4-6 MW/UM^2

    NOMINAL - 10-20 MW/UM^2

ROTATIONAL SPEED

    DIODE LASER POWER

MIN. SPACE MARK

    450 NS AT 1000 RPM

    130 NS AT 3000 RMP

Figure 27. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

■ FAIRCHILD

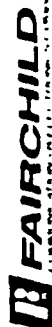## MEDIA LIMITATIONS

PARAMETERS	SPECIFICATION	IMPACT AND LIMITATION
TRACK PITCH	1.6 UM ± 0.1 UM	VARIATIONS PRODUCE CHANGES IN TRACKING SIGNAL AMPLITUDE. FOR NA > .55, TRACKING SIGNAL VARIATION IS LESS THAN ± 10%.
OBJECTIVE LENS NUMERICAL APERTURE	SUGGESTED .55-.6	VALUES > .55 REDUCE SENSITIVITY OF TRACKING SIGNAL TO TRACK PITCH VARIATIONS. HIGH NA VALUES REQUIRE HIGH PERFORMANCE FOCUS SERVO.
DATA DENSITY	SUGGESTED MAX. 416K BIT/MM^2 @ NA - .6 TRACK PITCH = 1.6 UM PIT PERIOD = 1.5 UM	READ SIGNAL AMPLITUDE DEPENDS ON THE MTF OF THE OBJECTIVE LENS. NA = .6 OBJECTIVE = 50% AT THIS DATA DENSITY (667 BIT/MM LINEAR DENSITY).
STORAGE CAPACITY	130 MM O.D. IMT = 53 MM OMT = 122 MM LINEAR DENSITY = 667 BITS/MM TOTAL = 300 M BYTES CAV	TOTAL CAPACITY WILL BE REDUCED BY PRERECORDED DATA AND ECC OVERHEAD

Figure 28. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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MEDIA LIMITATIONS

ROTATION
SPEED

1800 RPM

HIGHER ROTATION SPEED POSSIBLE
IF FOCUS AND TRACKING SERVOS
ARE ABLE TO COMPENSATE FOR
DISK MECHANICAL TOLERANCES.

WRITE
THRESHOLD

CURRENT A.I. MEDIA
REQUIRES 4.4 MW/μM^2
AT THE ROTATION
SPEED ABOVE.

CURRENT A.I. MEDIA WRITES WELL
FORMED FEATURES AT 10-12 MW
THROUGH NA = .6 LENS USING DATA
DENSITY AND ROTATION SPEED SUG-
GESTED ABOVE.
THRESHOLD OF FEATURE FORMATION
CORRESPONDS TO 2.7 MW THROUGH
A .6 NA LENS.

DATA
TRANSFER
RATE

FOR A LINEAR DATA
DENSITY OF 667 BIT/MM
DTR = 3.65 M BITS/SEC
@ 30 HZ

HIGHER DATA TRANSFER RATES WILL
REQUIRE HIGHER ROTATION SPEED
AND INCREASED SERVO PERFORMANCE.

LIFE

UNDER NORMAL OFFICE
ENVIRONMENT ESTIMATED
AT ≥ 10 YRS.

EOL IS DEFINED AS A BIT ERROR
RATE OF ≥ 1 x 10^4.

Figure 29. "Optical Memory System Study Presentation." Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

TRACKING SIGNAL PEAK AMPLITUDE
VS. NUMERICAL APERTURE
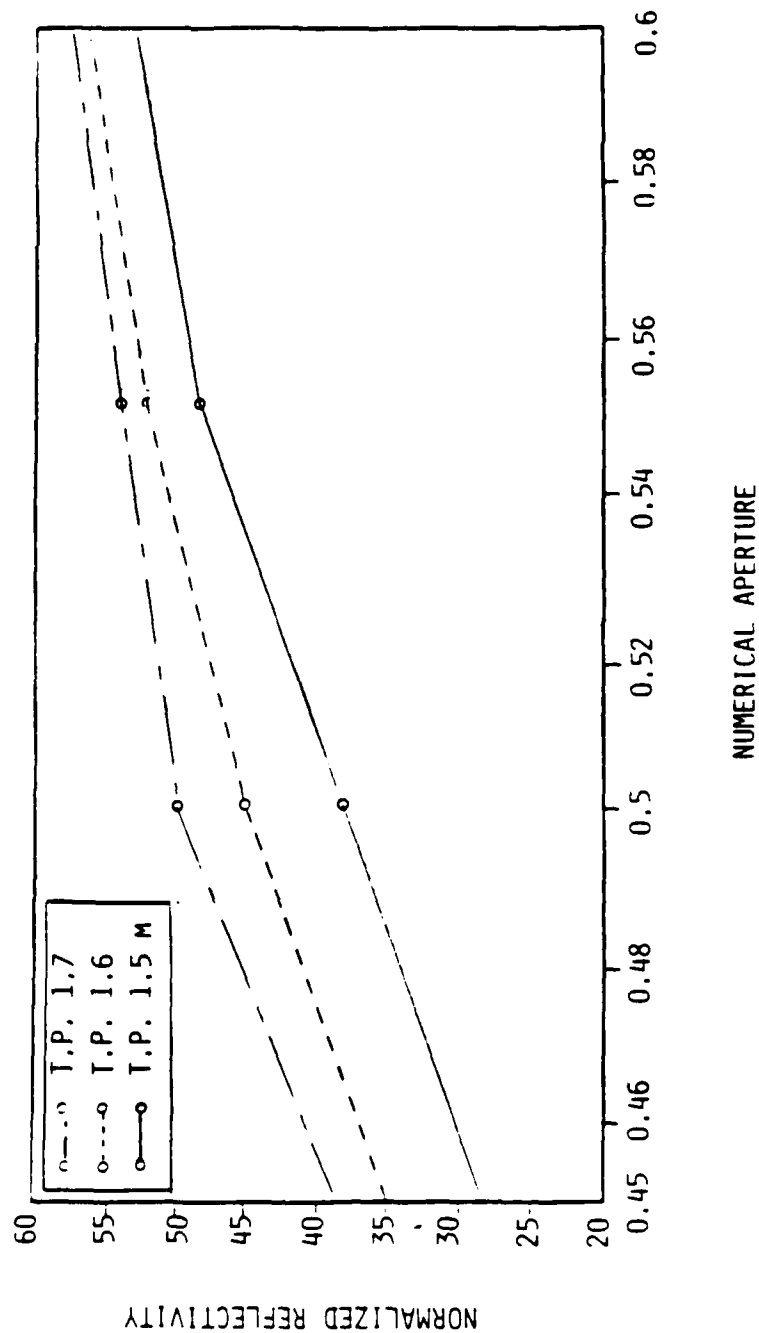
Figure 30. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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DATA CAPACITY VS. NUMERICAL APERATURE

TRACK PITCH = 1.6μM   ID=58. M   OD=122μM

DATA CAPACITY

NUMERICAL APERATURE

Figure 31.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

FAIRCHILD

SYSTEM PERFORMANCE

MEASUREMENT PARAMETER - ERROR RATE

INTEREST   - SIGNAL TO NOISE OVER ENTIRE
                           ENVIRONMENTAL OPERATING RANGE

Figure 32. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
            Communications and Electronics, 20301 Century Boulevard, Germantown,
            MD 20874-1182.

FAIRCHILD

LONG TERM LIMITATIONS

IMPACT AND LIMITATION

| PARAMETERS	
ALL PERFORMANCE PARAMETERS	DRIVE/MEDIA SYSTEM INTERACTION LIMITING FACTOR. MEDIA LIMITS ARE MORE A FUNCTION OF SUBSTRATE MATERIAL SELECTION RATHER THAN ACTIVE LAYER LIMIT.
ROTATION SPEED	LIMITED BY SUBSTRATE AND SERVO SYSTEM OF THE DRIVE.
LIFE	LIFE EXPECTANCIES AT THE EXTREME ENVIRONMENTAL CONDITIONS HAS NOT BEEN TESTED FOR TO DATE.

Figure 33.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD
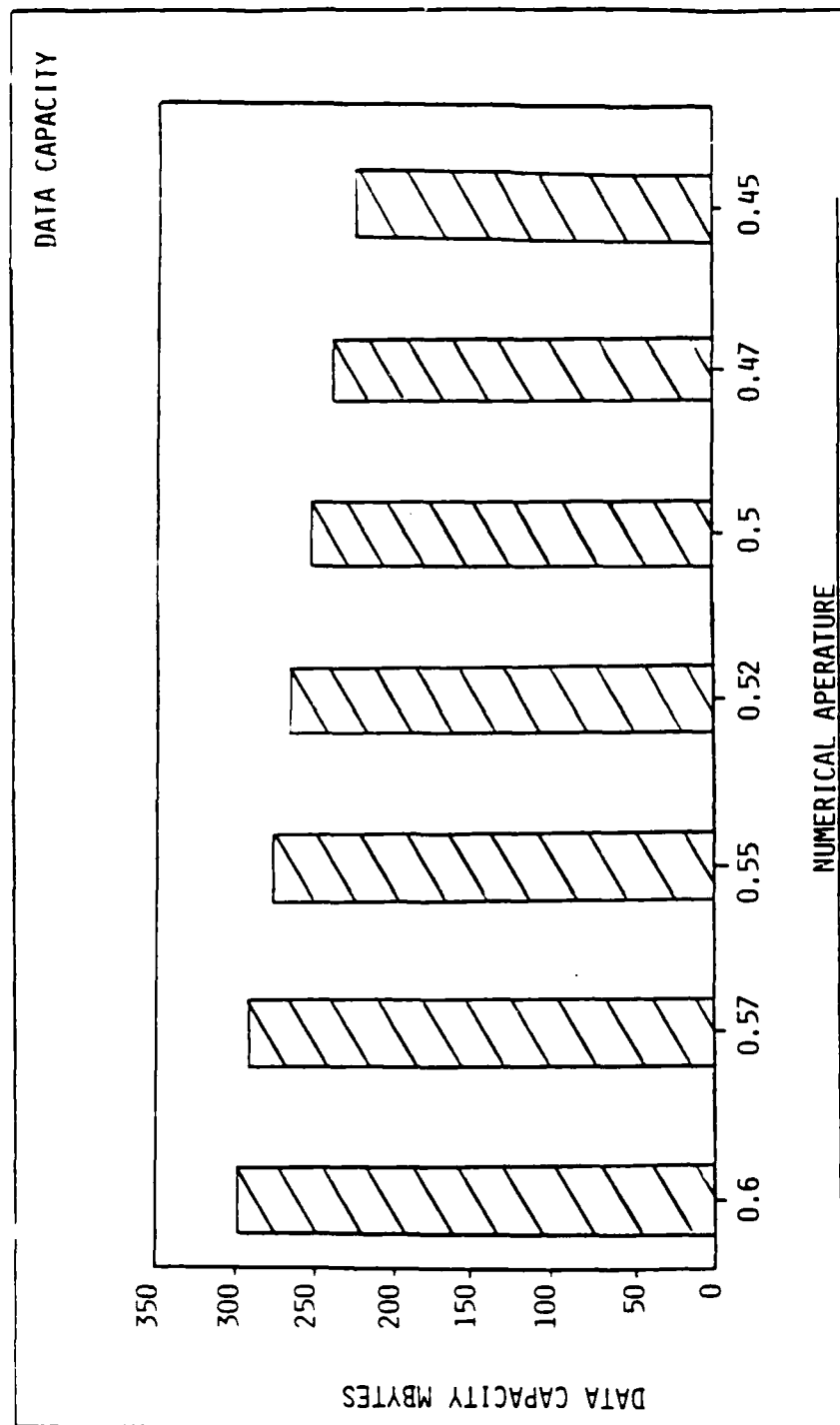
MEDIA

Figure 34. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

DEFINITIONS

SIGNAL — AMPLITUDE AND PHASE DIFFERENCE BETWEEN MARKS AND UNALTERED MEDIA.

WORM — HEATING SENSITIVE MEDIA LAYER - REMOVES MATERIAL AND EXPOSE HIGHER OR LOWER REFLECTIVITY LAYER. READOUT VIA AMPLITUDE AND PHASE MODULATION OF LIGHT.

ERASABLE — MAGNETIC OPTIC - HEATING PLUS BIAS MAGNETIC FIELD OVERCOMES COERCIVITY OF SENSITIVE LAYER. READOUT VIA ROTATION POLARIZED LIGHT.

Figure 35. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

MEDIA PROBLEMS

• GREATER STRESS DUE TO ENVIRONMENT

• ACCELERATE AND AUGMENT FAILURE MECHANISMS

• POLYMERS WILL NOT MEET TEMPERATURE, HUMIDITY,
  VIBRATION, SHOCK, ACCELERATIONS

<u>Figure 36.</u> "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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FAIRCHILD

ELEVATED ENVIRONMENTS PREDICTED MEDIA FAILURE MODES

- REDUCTION IN RE-READ STABILITY

- POSSIBLE RECIPROCITY FAILURE FOR WRITE THRESHOLD

- SUBSTRATE PHYSICAL AND CHEMICAL DEGRADATION

- SUBSTRATE MECHANICAL INSTABILITY UNDER VIB & ACCELERATED G-FORCES

Figure 37. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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GENERAL MEDIA PROBLEM ANALYSIS

FAIRCHILD

ENVIRONMENT	PERFORMANCE PARAMETER	LIMITER	POTENTIAL SOLUTIONS
CONDENSING HUMIDITY AND FROST	OPTICAL TRANSMITTANCE	NONE ALLOWED	CONTROLLED ENVIRONMENTAL BOX OR HERMETICALLY SEALED BOX
ALTITUDE	AIR GAP	DEPENDENT ON OPTICS OF DRIVE	"SUBSTRATE INCIDENT" WOULD ELIMINATE
TEMPERATURE	DISK STABILITY	-10°C TO 55°C (PMMA SUBSTRATE)	CHANGE OF THE SUBSTRATE MATERIAL
VIBRATION	DRIVE/DISK INTERACTION	UNKNOWN-NO DATA	DEPENDS ON LEVEL OF PROBLEM
ACCELERATION	VERTICAL PLANE DEFLECTION	UNKNOWN-NO DATA	CHANGE OF THE SUBSTRATE MATERIAL AND CONSTRUCTION
RADIATION EXPOSURE	OPTICAL TRANSMITTANCE, MATERIALS CHANGE, PERFORMANCE CHANGE, WRITTEN DATA CHANGE		

Figure 38. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

SUBSTRATES/LIMITATIONS

■R *FAIRCHILD*

POLYMERIC   - RUN OUT, TEMPERATURE, HYGROSCOPIC

GLASS   - FRAGILITY, DIFFICULT TO GROOVE, WEIGHT AND COST

ALUMINUM   - DIFFICULT TO USE, SURFACE ROUGHNESS, DIFFICULT
              TO GROOVE, COST

CAST EPOXY - PRODUCTION SCALE UP, COST, LIMITED TESTING

Figure 39. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
            Communications and Electronics, 20301 Century Boulevard, Germantown,
            MD 20874-1182.

OMTR/165

SUBSTRATE MATERIAL RATING
VS. ENVIRONMENT

FAIRCHILD

RATING - 0 = BAD/10 = BEST

MILITARY
INDUSTRIAL

P.M.M.A.   P.C.   GLASS   METAL   CAST P.C.

SUBSTRATE MATERIAL

Figure 40. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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FAIRCHILD

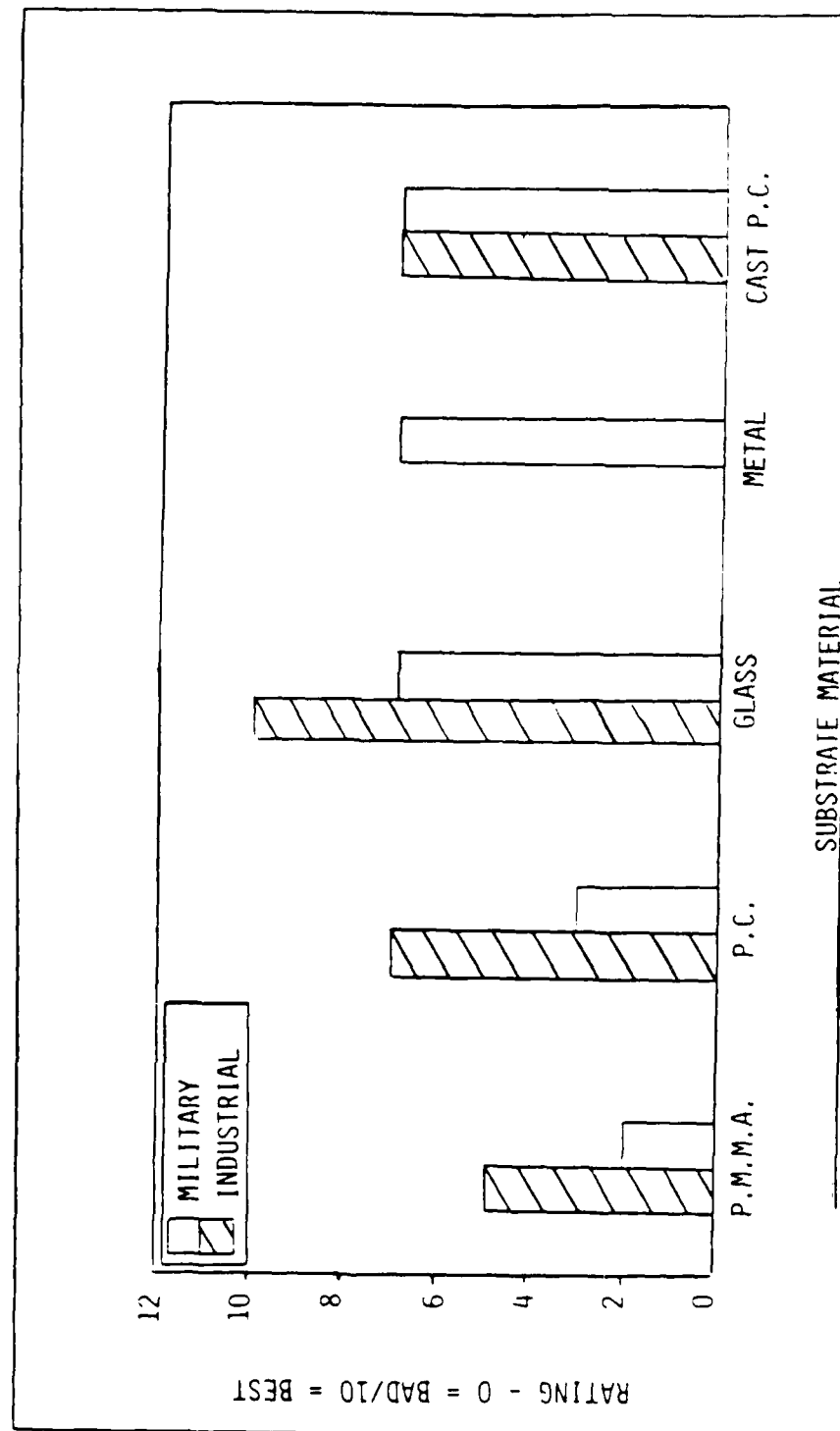MILITARY SPECIFICATION MEDIA DEVELOPMENT PLAN

Figure 41. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

MEDIA DEVELOPMENT OBJECTIVES

❘❘❘ FAIRCHILD

- THIN FILM MATERIALS EVALUATION/CHARACTERIZATION

- DESIGN OF THEN FILM MEDIA STRUCTURES

- SUBSTRATE SELECTION/EVALUATION

- DEVELOPMENT OF MOISTURE, CHEMICAL, AND THERMAL BARRIER LAYERS

- DEVELOP AND OPTIMIZE DEPOSITION PROCESS

- DEVELOP APPROPRIATE BONDING TECHNOLOGY

- MEASURE DYNAMIC PERFORMANCE OF MEDIA

- PERFORM ACCELERATED LIFE TESTS, RADIATION TESTING, ETC.,
  ON COATINGS AND COMPLETE DISCS

- CONDUCT COMPLETE RESEARCH ANALYSIS OF FAILURE MODES

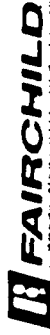- ITERATIONS FOR FINE TUNING THE ABOVE TASKS

Figure 42.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

ACTIVE LAYER SELECTION — MAJOR PARAMETERS

WRITE-READ STABILITY AT EXTREME ENVIRONMENTS

MECHANICAL AND CHEMICAL STABILITY AT EXTREME ENVIRONMENT

INTERFACE TO SUBSTRATE COMPATIBILITY

PROCESS COMPATIBILITY FOR SUBSTRATE

RADIATION RESISTANCE

EMP RESISTANCE

MANUFACTURABLE

RECIPROCITY LIMITS

- TEMPERATURE AND HUMIDITY SHOCK RESISTANCE

Figure 43.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

E FAIRCHILD

ACTIVE LAYER - TARGET SPECIFICATIONS

- WRITING ENERGY 5-6MW

- LIFETIME > 10 YEARS IN NON CONTROLLED ATMOSPHERE

- HIGH OPTICAL ABSORPTION AT 800-855 NM

- REFLECTIVITY IN UNWRITTEN AREAS 20-30%

- REFLECTANCE AND THRESHOLD TUNABILITY

- SATURATION AT 7-10MW WITH SHARP TRANSITIONS

- C/N 50DB, (55-60DB GOAL)

- BER AND DEFECT DENSITY $\sim 10^{-6}$

- 40 MBYTE CAPACITY (5 1/4", CAV)

- LOW FABRICATION COST

Figure 44. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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SUBSTRATE SELECTION - MAJOR PARAMETERS

- MECHANICAL STABILITY VS TEMP/HUMIDITY

- CHEMICAL STABILITY

- RADIATION RESISTANCE

- ACTIVE LAYER PROCESS COMPATIBILITY

- OPTICAL COMPATIBILITY

- TEMP & HUMIDITY SHOCK RESISTANCE

Figure 45. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

MEDIA DEVELOPMENT PLAN

Figure 46. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

FEASIBILITY OF COMMON WORM/ERASABLE DRIVE

Figure 47. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/173

FAIRCHILD

COMMON VS SINGLE FUNCTION DRIVE

SYSTEM ANALYSIS

● WRITE ONCE

● ERASABLE
  (MEDIA DECISION)

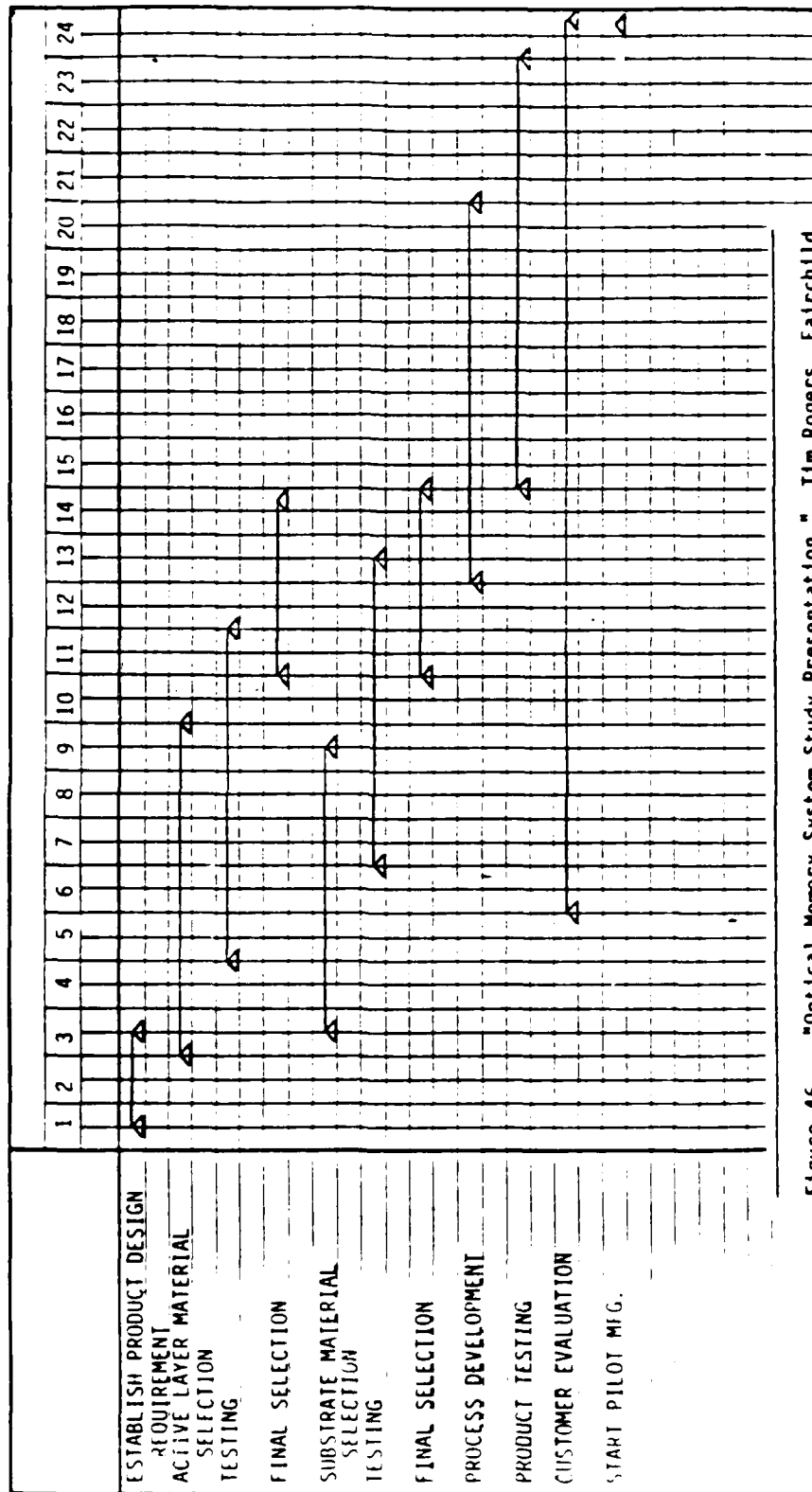● MULTI FUNCTION
  (MEDIA DECISION)

Figure 48. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

MEDIA ANALYSIS

Figure 49. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

ERASABLE OPTICAL MEDIA COMPARISON

FAIRCHILD
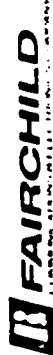
	Magneto-Optic	Phase Change	Dye/Polymer
Media Defect Error Rate	10^{-8}	10^{-8}	10^{-8}
CBER	10^{-12}	10^{-12}	10^{-12}
Read Cycle Degradation	none	some	some
Media Life (20C,50%)	> 8 yrs	> 3 yrs	> 25 yrs
Environmental Integrity			
o Temp & RH	> 60C,80%,	> 60C,80%	> 60C,80%
o Chemical	good	good	good
o EMI & Rad.	?	?	?
o Shock/Vib.	?	?	?
Failure Mechanism	Oxidation	Pinholes	Fatigue Photobleaching

Figure 50. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

MEDIA COMPARISON - CURRENT PERFORMANCE

FAIRCHILD

	MO	POLYMER DYE	PHASE CHANGE	REVERSIBLE DEFORMATION
STORAGE CAPACITY	0	0	0	0
ERROR RATE	+	-	0	0
ENVIRONMENT	0	0	0	0
LIFE	0	+	-	0
ERASE CYCLES	+	-	-	0
STATUS	++	-	-	-
COST	0	+	+	0

+ HIGHER PERFORMANCE
0 NEUTRAL
- LOWER PERFORMANCE

<u>Figure 51.</u> "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

SYSTEM COMPARISON

ITEM	WRITE ONCE	ERASABLE	MULTI-FUNCTION
OPTICAL MEDIA	IN PRODUCTION DOES NOT MEET MIL SPEC REQUIREMENTS	PILOT SAMPLES AVAILABLE DOES NOT MMEET MIL SPEC REQUIREMENT	NSD FROM ERASABLE REQUIRES TWO MEDIA DEV. PROGRAMS
OPTICAL HEAD	IN PRODUCTION RUGGED SAMPLES AVAILABLE DOES NOT MEET MIL SPEC REQUIREMENTS	NOT AVAILABLE MORE COMPLEX THAN W/O HEAD	NSD FROM ERASABLE
MECHANICAL	SHOCK AND VIBRATION ISOLATION TECHNIQUES ADAPTABLE FROM RUGGED OPTICAL W/O	HIGHER HEAD MASS REQUIRES DESIGN IMPROVEMENTS OVER W/O	NSD FROM ERASABLE
SERVOS	REQUIRES DEV. PROGRAM TO MEET HIGH INITIAL LOAD REQUIREMENT	MORE DIFFICULT DESIGN THAN W/O	NDS FROM ERASABLE
WRITE READ	CHANNEL WELL DEFINED	POSSIBLY LOWER SNR MAY REQUIRE BETTER DESIGN	NSD FROM ERASABLE

NSD - NO SIGNIFICANT DIFFERENCE

Figure 52. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
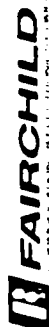
SYSTEM COMPARISON (CONT'D.)

ITEM	WRITE ONCE	ERASABLE	MULTI-FUNCTION
FORMAT AND CODES	INSENSITIVITY TO RANDOM HIGH INTENSITY ENVIRONMENT EFFECTS DESIRED	NSD	NSD
	DOES NOT MEET MIL SPEC REQUIREMENTS PROGRAM REQUIRED		NSD FROM ERASABLE TWO MEDIA DEV. PROGRAMS
ENVIRONMENTAL		MEDIA MAY BE MORE SUSCEPTIBLE TO ENVIRONMENTAL STRESS	

NSD - NO SIGNIFICANT DIFFERENCE

Figure 53. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

OPTICAL HEAD

Figure 54. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

180/OMTR

FAIRCHILD

WORM OPTICAL HEAD ASSEMBLY

Objective Lens Two Axis (7)
Actuator

Polarizing
Beamsplitter/
Quarter Wavelength
Plate Assembly (6)

Routing Mirror Assembly (5)

Correction
Prisms (4)

Detector

Focus Error Prism

Telescope Lens
Assembly (3)

Collection Lens (2)
Assembly

Laser Diode (1)

Figure ? "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1102.
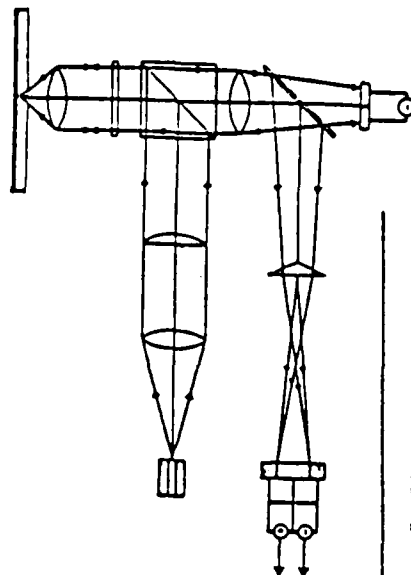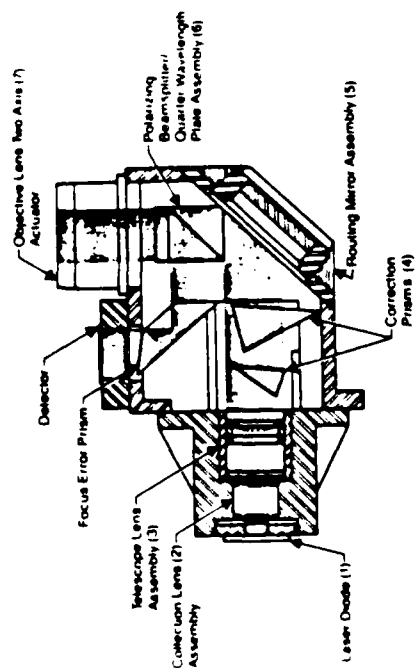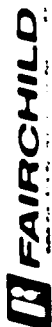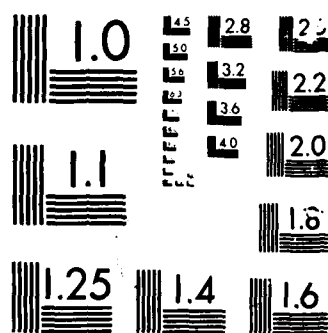
MAGNETO OPTIC HEAD ASSEMBLY

Figure 56. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

OPTICAL HEAD ELEMENTS

LASER ASSEMBLY   -   LASER, COLLIMATING/CORRECTING OPTICS,
                          PHOTODETECTORS, COOLER

OPTICAL ELEMENTS   -   OBJECTIVE, BEAM SPLITTER, MIRRORS,
                          PHASE PLATES, POLARIZERS

ACTUATORS   -   FOCUS, TRACKING

OPTOMECHANICAL   -   CONTAINS ALL OF THE ABOVE
PACKAGE

OPTIONS   -   PARTITION/SEPARATE OPTICAL HEAD ELEMENTS
                          FIXED AND MOVEABLE ASSEMBLIES
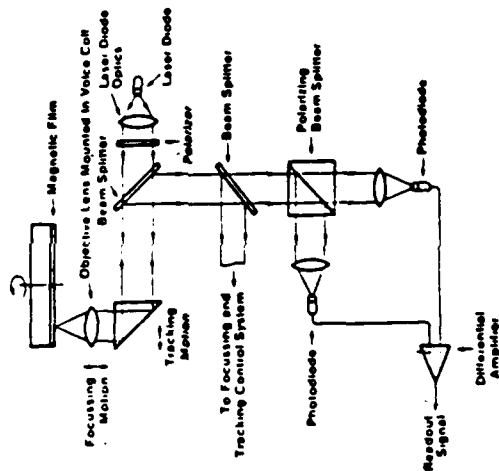
Figure 57.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
             Communications and Electronics, 20301 Century Boulevard, Germantown,
             MD 20874-1182.

OMTR/183

FAIRCHILD

DETECTION SYSTEM

PROBLEMS

- NOISE SUPPRESSION
- SIGNAL AMPLITUDE
- SEPARATION OF SERVO AND DATA SIGNALS
- STABILITY TO ENVIRONMENT
- SIGNAL BANDWIDTHS
- LIGHT LOSS

SOLUTIONS

- SEPARATE DATA AND SERVO LASER BEAMS
- ENVIRONMENTAL CONTROL

Figure 58. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

184/OMTR

FAIRCHILD

OBJECTIVE LENS

PROBLEM

- MULTIELEMENT DESIGN

- HIGH MASS

- HIGH POWER CONSUMPTION REQUIRED TO CONTROL

SOLUTION

- MOLDED, SINGLE ELEMENT, ASPHERIC OBJECTIVE

- SPLIT OPTICAL HEAD CONFIGURATION AIDS SOLUTION WITH
  LOWER MASS OBJECTIVE ASSEMBLY

Figure 59. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

OMTR/185

FAIRCHILD

ANALYSIS OF AVAILABLE OPTICAL HEADS

- ENVIRONMENTAL LIMITATIONS
- SIZE, WEIGHT, POWER PROBLEM
- DYNAMIC PERFORMANCE
- RESONANT MECHANICAL STRUCTURES
- UNSEALED ENCLOSURES
- ACTUATION DEFICIENCIES
- G LOAD TOLERANCE TOO LOW
- UNRELIABLE POSITION TRANSDUCER
- LASER POWER TOO LOW TO SUPPORT DATA RATES (5-10 MB/SEC)
- LASER TEMPERATURE CONTROL
- ALIGNMENT/DISTORTION PROBLEMS
- FASTENING/MOUNTING OF HEAD ELEMENTS INADEQUATE

Figure 60. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

LASER ASSEMBLY

ELEMENTS — LASER, COLLIMATING/CORRECTION OPTICS, MONITORING/PHOTODETECTION

PROBLEMS — ASTIGMATISM, ASYMMETRICAL EMISSIONS, BEAM POINTING, INSTABILITIES, NOISE, TEMPERATURE RANGE, POWER OUTPUT

— AVAILABLE IN 20 MW - 40 MW POWER RANGE
  10K - 100K HOURS LIFE

SOLUTIONS — MATCHING LASER TO OPTICS

— MAINTAIN HIGH ALIGNMENT TOLERANCE

— AVAILABILITY OF IMPROVED DEVICES IN NEAR TERM

— CONTROLLED TEMPERATURE TO MAINTAIN PERFORMANCE

— PROJECTIONS FOR 100MW, 1M HR, MULTIPLE BEAM DEVICES
  (NOT IN SAME DEVICE)

Figure 61. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
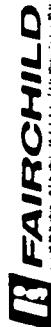
OMTR/187

FOCUS AND FINE TRACKING SERVO CONSIDERATIONS

FAIRCHILD

● PERFORMANCE REQUIREMENTS — FOCUS: ± 0.25 µM FOR UP TO 250 µM VERTICAL ACCELERATION FINE TRACKING: ±0.1 µM FOR UP TO 100 µM RADIAL RUNOUT

● CLOSED-LOOP COARSE SEEK — ELIMINATES MAJOR PART OF RADIAL RUNOUT. FINE TRACKING CAN BE OPTIMIZED FOR EXTENDED ENVIRONMENT. POSSIBLE PROBLEMS INCLUDE COUPLING OF COARSE AND FINE SERVO FEEDBACK AND FORM FACTOR MAINTENANCE

● RESOLUTION/ACCURACY — MAINTAINING 1.6 µM ± 0.1 µM TRACKS AND 2MM ± 0.25 µM FOCUS IS EASY IN BENEVOLENT ENVIRONMENT. HIGH G LOADS, SHOCK, VIBRATION MAKE THIS TOUGH IN HIGH-PERFORMANCE AIRCRAFT

● BANDWIDTH — DICTATED BY DISK CHARACTERISTICS AND EXTENDED MILITARY ENVIRONMENT. 3KHZ FOR FOCUS SERVO AND 5KHZ FOR FINE TRACKING SERVO

● POWER — WILL INCREASE DUE TO ENVIRONMENTAL FORCES

● STABILITY — IN ADDITION TO RECOVERING FROM HIGH G FORCE LOADS, SERVOS MUST COMPENSATE FOR MISALIGNMENT OF OPTICS AND DETECTORS, LASER POINTING ERRORS, AND NON-UNIFORM VOICE COIL HEATING

Figure 62. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

FOCUS AND FINE TRACKING SERVO CONSIDERATIONS (CONT'D.)

● REACTION TO HIGH G FORCES   -   SHOCK, VIBRATION, AND INERTIAL FORCES WILL HAVE
FREQUENCY COMPONENTS UPPER BOUNDED BY THE SERVO
BANDWIDTHS. ANTICIPATION SENSORS PROBABLY NOT
REQUIRED. BUT, NEED BEEFY VOICE COILS/ACTUATORS,
WHICH REQUIRE MORE SPACE AND POWER AND DISSIPATE
MORE HEAT. THERE IS ALSO A CONCERN THAT HIGH
VIBRATION LEVELS MAY CAUSE COUPLING BETWEEN FOCUS
AND TRACKING SERVOS.

Figure 63.   "Optical Memory System Study Presentation."   Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

OMTR/189

INTEGRATED VS. SEPARATE OPTICAL HEAD CONSIDERATIONS ⬛ *FAIRCHILD*

INTEGRATED

+ ALL COMPONENTS IN A SINGLE PACKAGE
+ EASIER TO BUILD
+ OPTICAL PATHS SHORTER
+ CAN HERMETICALLY SEAL AS A UNIT

- LARGE MASS (ACTUATOR DESIGN ISSUE; INCREASES REACTIONS TO INERTIAL FORCES)
- ALL COMPONENTS SUBJECTED TO ACTUATOR FORCES
- LARGER SIZE (PHYSICAL DIMENSIONS)

SEPARATE

+ REDUCE MASS
+ FASTER SEEKS
+ FEW COMPONENTS SUBJECTED TO ACTUATOR FORCES
+ SMALLER SIZE OF MOVING PART

- OPTICAL DESIGN MORE DIFFICULT
- BEAM POINTING STABILITY PROBLEMS
- MAINTAINING ALIGNMENT TOUGHER
- INCREASES OTHER DRIVE TOLERANCES

Figure 64. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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[ID] FAIRCHILD

SEPARATE WRITE AND READ BEAMS OF DIFFERENT WAVELENGTH

ADVANTAGES:

- PERMITS DRAW

- AVOIDS SATURATION OF SERVO TRANSDUCERS
  DURING WRITING

- PERMITS CONTINUOUS, UNINTERRUPTED
  READING

- EASIER IMPLEMENTATION OF CONTINUOUS
  SERVO

- HIGHER CAPACITY
- HIGHER DATA RATE
- LOWER ERROR RATE
- HIGHER THROUGHPUT BY ELIMINATING
  MULTIPLE REVOLUTIONS

DISADVANTAGES:

- PROBLEMS OF KEEPING BEAMS MUTUALLY ALIGNED
- INCREASED ALIGNMENT DIFFICULTY WITH TEMPERATURE EXCURSIONS
- INCREASED COMPLEXITY
- INCREASED COST

RECOMMENDATION:

- IMPLEMENT AND TEST BOTH APPROACHES OVER ENVIRONMENTAL AND INERTIAL INPUT RANGES

Figure 65. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

OMTR/191

LASER COOLER PERFORMANCE

EXAMPLES

MAINTAIN

25°C LASER TEMP.   30 MW DIODE LASER

CASE I - 50°C AMBIENT

- 142 MW ELECTRICAL INPUT TO LASER
  30 MW LIGHT OUTPUT
  112 MW HEAT FROM LASER

- 280 MW ELECTRICAL INPUT TO COOLER (39% EFFICIENT)
- 392 MW HEAT INTO ENVIRONMENT

CASE II - 120°C AMBIENT

- 112 MW HEAT FROM LASER
- 1800 MW ELECTRICAL INPUT TO COOLER (6% EFFICIENT)
- 1912 MW HEAT INTO ENVIRONMENT

Figure 66.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

Figure 67. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

Figure 68. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

CRITICAL HEAD PARAMETERS (CONT'D.)

FAIRCHILD

VIBRATION INPUT   TBD   MAINTAIN FOCUS/TRACKING AND
                                              ERROR RATE

SUSTAINED ACCELERATION 7.5G   CONSISTENT WITH MILITARY ENVIRONMENT

HEAD DESIGN SUPPORTS   CAPACITY - 400 MB CAV
                                              RATE   - 10 MB/S
                                              FINE SEEK- 1MS
                                              MAX SEEK - 80MS
                                              ENVIRONMENT
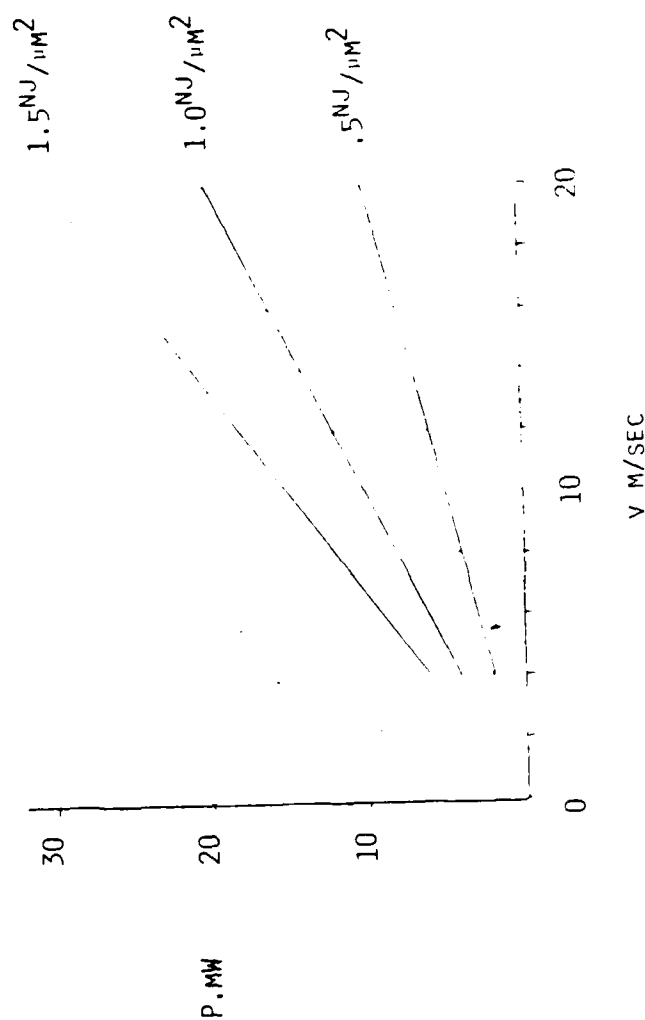
Figure 69.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
             Communications and Electronics, 20301 Century Boulevard, Germantown,
             MD 20874-1182.

OMTR/195

FAIRCHILD

DISK DRIVE

Figure 70. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

DRIVE ELEMENTS

- BASEPLATE

- HEAD/DISK CHASSIS

- SPINDLE MOTOR

- HEAD DISK ASSEMBLY (HDA)

- DRIVE CONTROL ELECTRONICS

- SHOCK/VIBRATION ISOLATORS

- CARTRIDGE LOAD/UNLOAD MECHANISM

Figure 71. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

DRIVE PROBLEMS

FAIRCHILD

- SHOCK AND VIBRATION ISOLATION METHODS NOT ADEQUATE FOR MILITARY ENVIRONMENT

- CONSTRUCTION OF SUPPORT STRUCTURES NOT RUGGEDIZED

- CONTAMINATION CONTROL METHODS NOT APPLICABLE

- COMPONENTS NOT MILITARY QUALITY LEVEL

- RADIATION SENSITIVITY IN OPTICAL COMPONENTS

Figure 72. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

SERVO SYSTEMS

- LASER POWER CONTROL

- OPTICAL BEAM FOCUS

- TRACK FOLLOWING

- SPIN MOTOR CONTROL

COMPLEX DRIVES EMPLOY BEAM ALIGNMENT, MATCHING UNIT POWER TO MEDIA

Figure 73. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/199

B FAIRCHILD

SPIN SERVO/MOTOR

- CONTROL VELOCITY TO $<1\%$

- BRUSHLESS D.C. MOTOR, ENCODER FEEDBACK

- EFFICIENCY AND LOW INERTIA REQUIRED TO REACT TO DISTURBANCES

- RESPONSE CURVE IMPLEMENTED WITH SAMPLED CONTROL SYSTEM

- RADIAL RUN OUT $\setminus$ 10µM, TILT $\setminus$ 5M RADIANS

ABOVE REQUIRED TO MEET EXPECTED LOADS

Figure 74. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

200/OMTR

FAIRCHILD

FOCUS SERVO

- COMPONENTS DISK RUN OUT, ACCELERATION, SUBSTRATE THICKNESS AND TILT

- FOCAL POINT HELD ± 2.0 µM OVER ± 200µM

- ENCASE OBJECTIVE LENS IN LINEAR MOTOR ASSEMBLY

- CAN MOVE ALTERNATE ELEMENTS - MIRRORS, PRISMS, LENSES

- TRANSDUCERS TECHNIQUES - ASTIGMATIC, CRITICAL ANGLE, KNIFE EDGE

- EACH TECHNIQUE HAS ERROR, NON LINEARITY AND LIMITED RANGE

FUTURE

- FLYING ELEMENTS - REDUCED COST AND MASS
  HIGH PERFORMANCE

- FLYING HEADS

- SELF FOCUSING SUBSTRATES

Figure 75. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/201

FAIRCHILD

TRACKING SERVO

• TRANSLATES OR TILTS ON OPTICAL ELEMENT

• TRACKING SIGNAL COMES FROM PREFORMATTED TRACKS OR GROOVES

FUTURE DIRECTIONS

• DISCONTINUES TRACKING ERROR SIGNAL LIMITS ACCESS TIME

• BIPOLAR VERSION OF SIGNAL WILL BOAST RATES

• LOWER MASS MOVING ELEMENT

• HIGH EFFICIENCY MOTORS

• FIXED OPTICS

Figure 76. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

202/OMTR

FAIRCHILD

LASER POWER CONTROL

- MAINTAIN CONSTANT LASER POWER (READ AND WRITE)

- INSURE SERVO TRANSDUCER SIGNAL PRODUCES CONSISTENT AND ACCURATE INDICATION OF FOCUS AND TRACK ERROR WHILE PRESERVING READ SIGNAL FIDELITY

- INSURE WRITING PROPERLY DURING VELOCITY, MEDIA SENSITIVITY AND TEMPERATURE CHANGES

- PHOTO DIODE SAMPLES PORTION OF LASER POWER

RECOMMEND A WRITE CONTROL SYSTEM OPERATING IN SAMPLE DATA MODE READ CONTROL SYSTEM CONTINUES

Figure 77. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/203

FAIRCHILD

RADIAL ACTUATION TRACKING

COARSE AND FINE ACTUATORS

COARSE - LARGE RANGE LIMITED BW

FINE - SMALL RANGE HIGH BW

100 μM OF RADIAL RUN OUT IS CONTROLLED TO 0.1 μM

COARSE POSITION SERVO

STEPPER MOTORS

D.C. SERVO MOTORS WITH BAND, RACK AND PINION ACTUATORS

FEEDBACK SIGNAL - FROM TRACKING ACTUATOR

HIGH PERFORMANCE CLOSED LOOP SERVO COARSE ACTUATOR
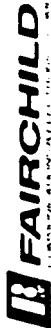
FINE ACTUATOR

VOICE COIL

RANGE ±10 TO ± 200 TRACKS

Figure 78. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

204/OMTR

COARSE ACTUATOR CRITERIA

PARAMETER	WEIGHTING FACTOR	SPLIT BAND	RACK & PINION	LEAD SCREW	WIRE DRIVE
HOLDING FORCE	1	3	2	1	4
SEEK TIME	1	3	2	1	4
REQUIRED SPACE	1	1	2	4	3
RESOLUTION	2	4	2	1	3
WEAR	3	1	3	4	2
HYSTERISIS	3	3	1	2	4
LOW FRICTION	3	1	3	4	2
COST	5	1	3	4	2
LUBRICATION	5	NO	YES	YES	NO
DEBRIS GENERATION	5	NO	YES	YES	POSSIBLY
OVERALL		3	1	2	4

RECOMMENDATION: RACK AND PINION

Figure 79. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

CARTRIDGE LOAD/UNLOAD MECHANISM

CONCERNS

- ACCURACY OF ALIGNMENT
- REPEATABILITY
- STRUCTURAL INTEGRITY

QUESTION AS TO VIABILITY OF COMMERCIAL TYPE CARTRIDGE APPLICATION

Figure 80. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
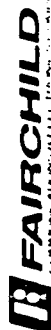
FAIRCHILD

DESIGN RECOMMENDATIONS

- DUAL RADIAL ACTUATORS

- RACK AND PINION COARSE ACTUATOR

- D.C. SERVO MOTOR

- MICROPROCESSOR BASED CONTROL

- FOCUS SERVO BW 3 KHZ

- TRACKING SERVO BW 5 KHZ

- CONTINUOUS SERVO FORMAT

- ACTUATORS TO MEET INERTIAL FORCES AND ACCESS TIME

Figure 81. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182,

FAIRCHILD

DRIVE DEVELOPMENT PROGRAM

- HEAT EXCHANGE SYSTEM DESIGN

- THERMAL COMPENSATION

- REMOVABLE MEDIA SYSTEM

- COMMON DRIVE

- CONTAMINATION CONTROL SYSTEM

- VIBRATION STABILIZATION/ISOLATION SYSTEM

- SERVO MOTORS, ACTUATORS AND CONTROL THAT MEET THERMAL
  AND INERTIAL REQUIREMENTS

- OPTIMIZE RADIAL SERVO ARCHITECTURE

- ABOVE CONSISTENT WITH DRIVE FORM FACTOR

Figure 82. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
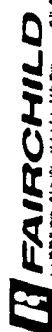Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

208/OMTR

FAIRCHILD

SYSTEM PACKAGING

Figure 83. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OVERALL PACKAGING DESIGN CONSIDERATIONS

AVIONICS EQUIPMENT BAY APPLICATIONS

- DESIGN DRIVE, PWBs, AND POWER SUPPLY TO FIT IN #6 LINE REPLACEMENT
  UNIT (LRU) 7.5 WIDE X 7.64 HIGH X 12.76 LONG

- DESIGN TO COMPLY WITH DOD-STD-1788

- COOLING AIR AVAILABLE

- NOT ESSENTIAL TO HAVE RAPID ACCESS TO MEDIA

Figure 84. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

210/OMTR

FAIRCHILD

MECHANICAL PACKAGING

● OVERALL PACKAGING CONSTRAINTS (WEIGHT, DIMENSIONS, ETC.)

    - AVIONICS EQUIPMENT BAY
    - PANEL MOUNTED EQUIPMENT

● THERMAL DESIGN METHODOLOGY

    - FREE CONVECTION DESIGN
    - FORCED AIR COOLED DESIGN

● VIBRATION/SHOCK DESIGN METHODOLOGY

Figure 85. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

Ⓡ FAIRCHILD

#6 LRU DRIVE UNIT PACKAGING

TEST CONN NO 1

TEST CONN NO. 2

OPTICAL MEDIA IN NAS HOOK LOCKED POSITION (HANDLE AT 90°)

COOLING AIR CLEARANCE

OPTICAL DISK DRIVE ASSY.

COOLING FIN STRUCTURES

BACKPLANE & 5 & 12 VOLT POWER SUPPLY PWBs

VIBRATION ISOLATOR ON STANDOFF

INSULATION

Figure 86. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

VIBRATION ISOLATION

● SINUSOIDAL AND RANDOM VIBRATION ISOLATION CONSIDERED IN TASK 2 DISCUSSION

● CONCLUSION: THE LOW FREQUENCY END OF THE SPECTRUM REQUIRES SPECIAL ATTENTION

● STRATEGY FOR MINIMIZING LOW FREQUENCY STRUCTURAL DISTRUBANCES

● ATTENUATION OF EXTERNAL FORCING FUNCTIONS:

- USE TWO-STAGE ISOLATION SYSTEM
- LOW BAND PASS PERIODIC FORCE ISOLATORS
- HIGH BAND PASS APERIODIC FORCE ISOLATORS
- AVOID ANISOTHERMAL ISOLATOR MATERIAL
- PROVIDE LARGE SWAY SPACE INSIDE DRIVE

● ATTENUATION OF INTERNAL FORCING FUNCTIONS

- AVOID USE OF SHEET METALS
- USE HIGH TEMPERATURE POLYMERS
- USE STRUCTURAL DECOUPLING ELEMENTS

● ATTENUATION OF SYMPATHETIC RESONANCES

- FREQUENCY DETUNE EIGENVALUES OF LINKED COMPONENTS
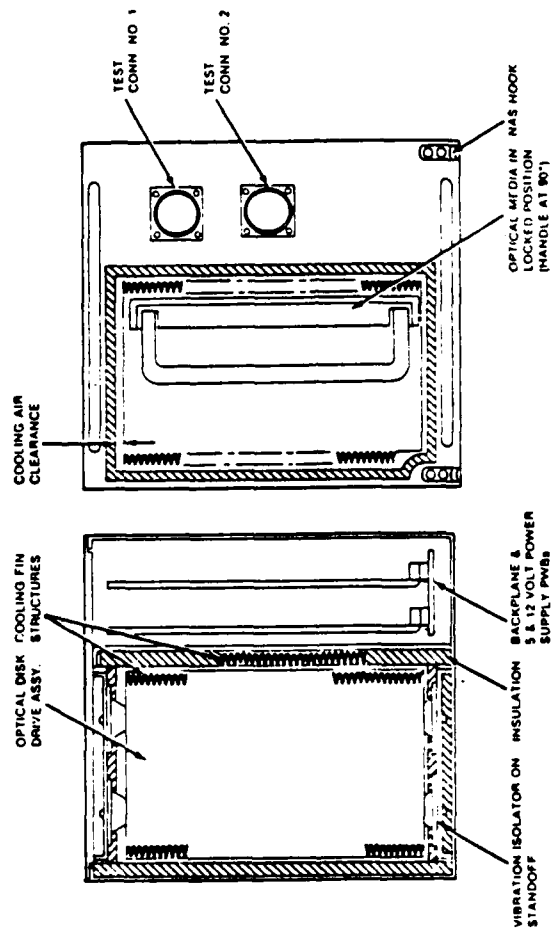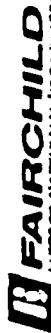- PHASE DETUNE EIGNEVALUES OF UNLINKED COMPONENTS

Figure 87. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/213

SINUSOIDAL VIBRATION LEVELS

SEEN BY THE DRIVE

● ASSUMES COMMERCIALLY AVAILABLE ISOLATORS "FILTERING" CURVE IIIA MILITARY INPUT.

● CAN BE CONVERTED TO G LOADING BY RELATION INDICATED ON GRAPH.

● RESULTS:

- MAXIMUM D.A. OF
  0.20 AT 13 Hz

- MAXIMUM G's OF
  2.72 AT 23 Hz

- AT 1800 RPM =
  30 Hz
  D.A. = .055 INCH
  G's = 2.52 G's

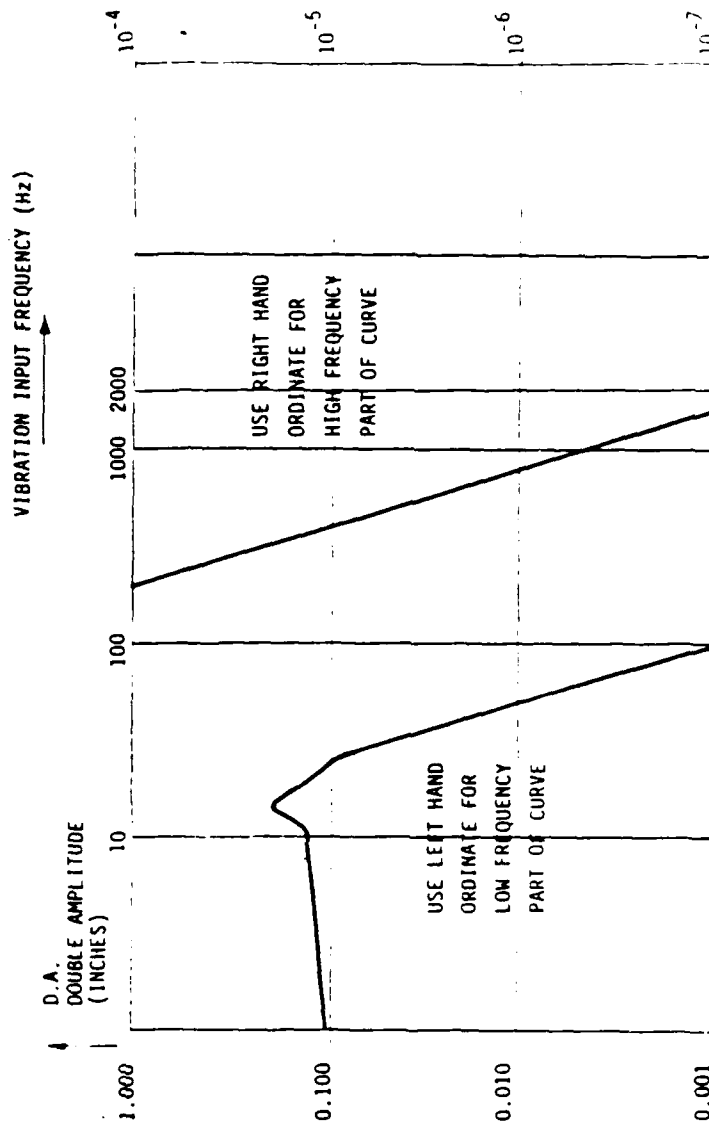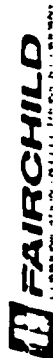- AT 3000 RPM =
  50 Hz
  D.A. = .009 INCH
  G's = 1.148 G's

Figure 88. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FREE CONVECTION PARAMETRIC ANALYSIS

● THERMAL ANALYSIS INPUTS

  - DRIVE DIMENSIONS
  - FIN STRUCTURE
  - AMBIENT CONDITIONS

● RESULTS

  - SURFACE AREA ENHANCEMENT OR
    OTHER MEANS TO DECREASE DRIVE
    TEMPERATURE ESSENTIAL

  - DESIGNERS MUST CONSIDER EFFECT
    OF ALTITUDE

  - DRIVES OPERATED IN FREE
    CONVECTION ENVIRONMENTS MUST
    DISSIPATE MINIMAL ENERGY

  - 10 WATT DRIVE → ΔTs OVER AMBIENT
    OF 20°C OR LESS

    20 WATT DRIVE → ΔTs OVER AMBIENT
    OF 40°C OR LESS

  - DRIVE INTERNAL TEMPERATURES WOULD
    BE 5 TO 10°C HIGHER AND WELL OVER
    PRESENT DAY MEDIA CAPABILITIES

Figure 89. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/215

FORCED AIR COOLING PARAMETRIC ANALYSIS

FAIRCHILD

- THERMAL ANALYSIS INPUTS

  - DRIVE SURFACE AREA
  - AIR MASS FLOW RATE
  - AIR INLET AIR TEMPERATURE
  - HYDRAULIC DIAMETER (BASED ON FIN SPACING AND CLEARANCE AROUND THE DRIVE)

- RESULTS

  - FLOW RATE OF 0.5 LB/MINUTE RESULTS IN CASE TEMPERATURES/INTERNAL TEMPERATURES IN THE RANGE OF 54 TO 66°C
  - STATIC PRESSURE CHANGE THROUGH A TYPICAL PACKAGE IS < 2 INCHES H_2O

FORCED AIR COOLING ANALYSIS

$DHYD = .188$ inches
$TINLET = 48°C$
$AREA = 5.78$ ft^2

T_{CASE} (°C)

82.2
76.7
71.1
65.5
60.0
54.4
48.8

0.1 LB/MIN
0.3 LB/MIN
0.5 LB/MIN
0.7 LB/MIN
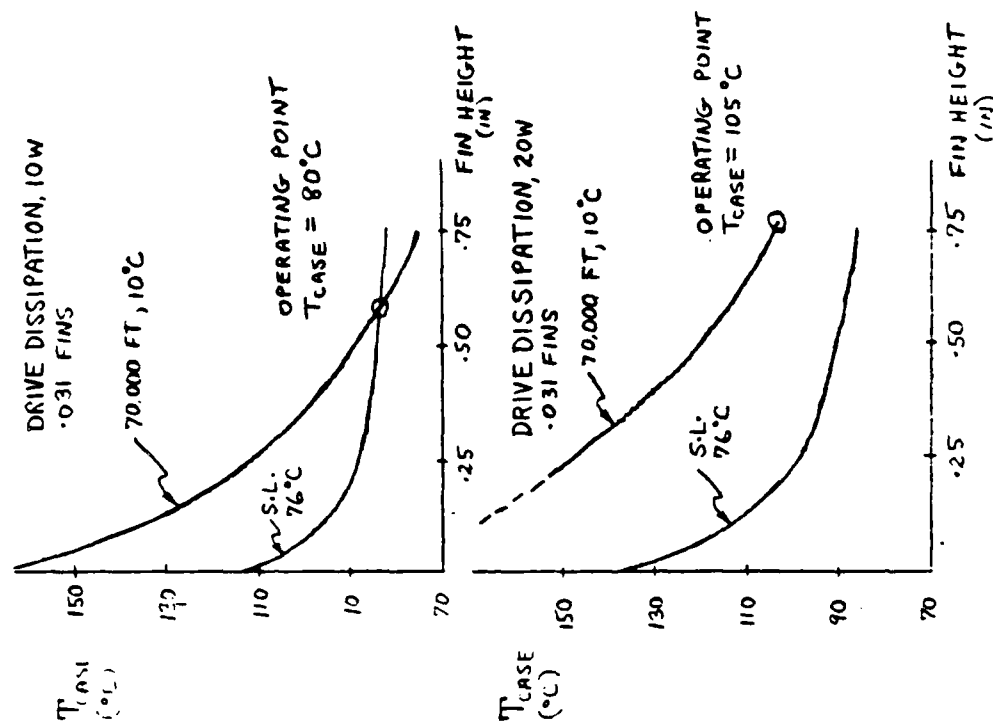0.9 LB/MIN

DRIVE POWER DISSIPATION (WATTS)

20   30   40

Figure 90. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
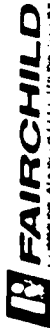
216/OMTR

FAIRCHILD

ERROR MANAGEMENT

Figure 91. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/217

⚡ FAIRCHILD

ERROR DETECTION AND CORRECTION (EDAC)

PURPOSE:

- IMPROVE OPTICAL DISK CHANNEL PERFORMANCE BY DETECTING AND CORRECTING ERRORS

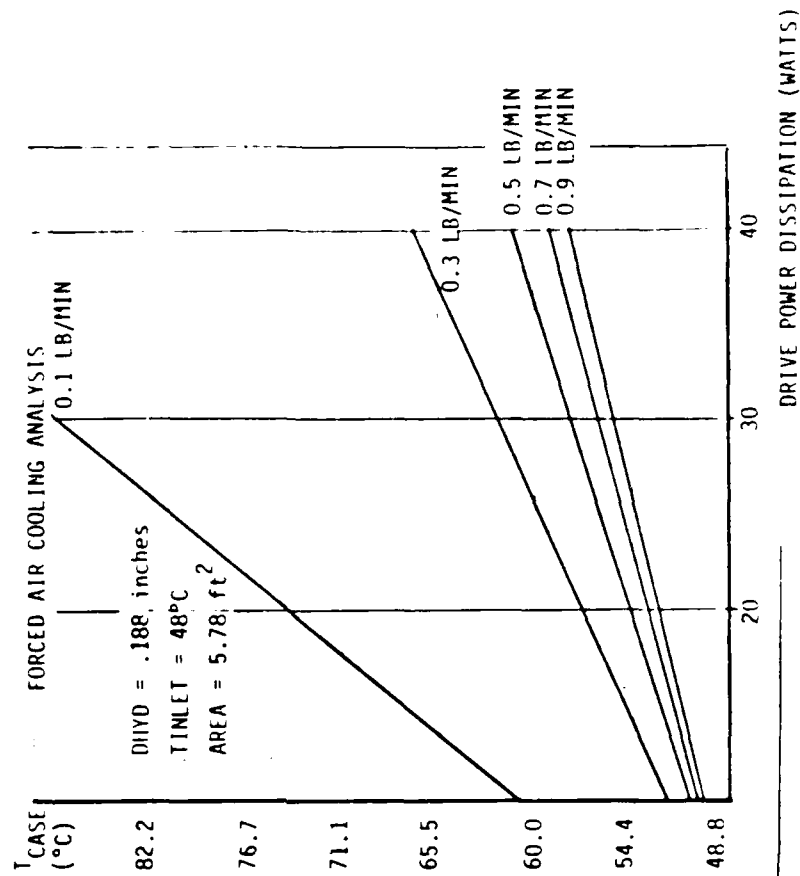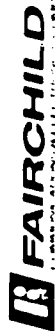- THE HIGH RAW DATA ERROR RATE OF THE OPTICAL DISK REQUIRE THE USE OF EDAC

Figure 92. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

ERROR CONTROL

- DEFINITION - TECHNIQUES TO REDUCE THE OCCURRENCE OF ERRORS IN THE SYSTEM AND THE METHODOLOGIES USED TO DETECT AND CORRECT ERRORS DURING TRANSMISSION

- METHODS TO REDUCE NUMBER OF ERRORS

  - RUGGEDIZE OPTICAL DRIVE COMPONENTS
  - PROTECT SYSTEM FROM EXTREME ENVIRONMENTS AND CHANGES
  - REDUCE THE MEDIA DEFECT RATE AND BURST LENGTH CHARACTERISTICS
  - USE ERROR TOLERANT CODING AND DECODING SCHEMES

- METHODS USED TO DETECT ERRORS

  - PARITY CHECKING
  - CONSTANT RATIO CODES (4 OF 8, 2 OF 7, ETC.)
  - CYCLIC REDUNDANCY CHECKS (CRC CODES)
  - FIRE CODES
  - COMPUTER GENERATED POLYNOMIAL CODES
  - REED-SOLOMON CODES

- METHODS USED FOR ERROR CORRECTION

  - FIRE CODES
  - HAMMING CODES
  - REDUNDANT SECTOR CODES
  - REED-SOLOMON CODES
  - INTERLEAVED REED-SOLOMON CODES

Figure 93. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

EDAC: CODE REQUIREMENTS

- DEFECT LENGTH PROBABILITY DISTRIBUTION IS

$$P = [1 + X/(L \cdot (M - 1))]^{-M}$$

WHERE,

M = 4
L = 2
X, DEFECT LENGTH IN NUMBER OF BITS
P, PROBABILITY THAT ERROR BURST IS X BITS
OR GREATER IN LENGTH

- BEGINNING-OF-LIFE DEFECT EVENT RATE = 1.0E-5 DEFECT EVENTS PER BIT

- END-OF-LIFE DEFECT EVENT RATE = 1.0E-4 DEFECT DEVENTS PER BIT

- SECTORS WITH MORE THAN $2'$ BYTES IN ERROR ARE RETIRED AT BEGINNING-OF-LIFE (EXCEPT READ-ONLY DISKS) OR AT WRITE TIME

- ASSUME THAT END-OF-LIFE DISTRIBUTION IS THE SAME AS THAT FOR BEGINNING-OF-LIFE EXCEPT THAT MAXIMUM DEFECT LENGTH IS 100 BITS

Figure 94. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

Figure 95. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

EDAC: CODE PERFORMANCE CRITERIA

● ACHIEVE AN UNCORRECTABLE SECTOR EVENT RATE OF LESS THAN 1.0E-13 UNCORRECTABLE SECTORS PER BIT

● LOW MISCORRECTION PROBABILITY. EDAC "CORRECTS" VALID DATA WHEN IT TRIES TO CORRECT A BURST OF ERRORS THAT EXCEEDS IN LENGTH THE CAPABILITY OF THE CODE.

● CIRCUIT COMPLEXITY AND COST. LSI ICs ENABLE COMPLEX CODES TO BE IMPLEMENTED

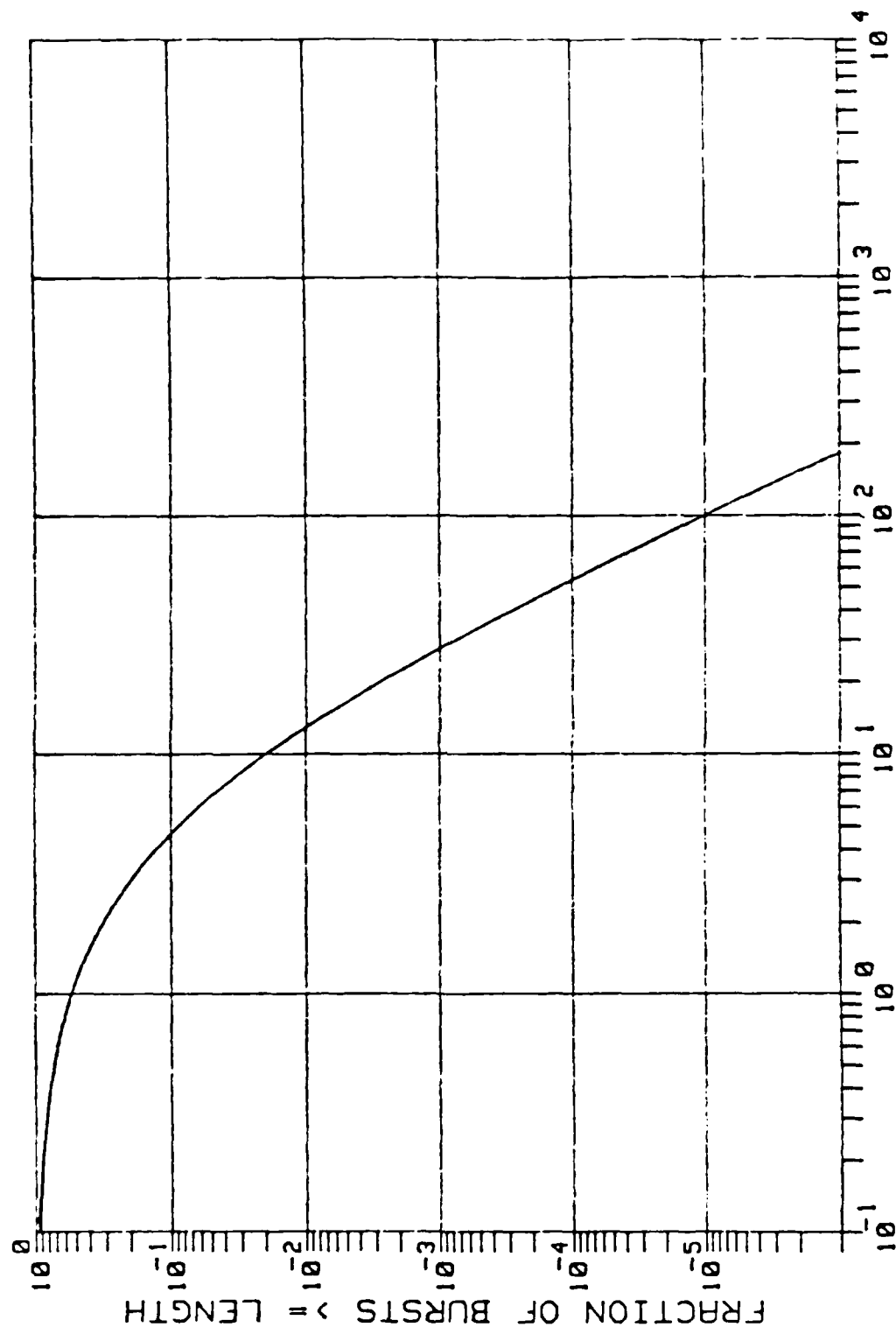● PROCESSING TIME. FASTER ICs AND MICROPROCESSORS ARE REDUCING PROCESSING TIME.

Figure 96. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

EDAC: RECOMMENDED CODE
INTERLEAVED REED-SOLOMON (RS) CODE

- CORRECTS ALL ERRORS WITH LENGTH OF 8 SYMBOLS (8BITS) OR LESS

- MINIMUM DISTANCE = 17 SYMBOLS

- FIVE INTERLEAVES USED IN BLOCK OF 512 SYMBOLS

- 16 REDUNDANCY SYMBOLS PER INTERLEAVE, 16% OVERHEAD

- GENERATOR POLYNOMIAL OF DEGREE 16 WITH COEFFICIENTS FROM
  GF(256)

- DECODING STEPS:

  - COMPUTE SYNDROMES
  - GENERATE ERROR-LOCATOR POLYNOMIAL
  - FIND ROOTS OF THE ERROR-LOCATOR POLYNOMIAL
  - TAKE LOGS OF THESE ROOTS TO COMPUTE ERROR LOCATIONS
  - COMPUTE ERROR VALUES

Figure 97. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/223

EDAC: RECOMMENDED CODE
INTERLEAVED RS CODE

FAIRCHILD
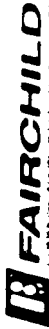
- PROBABILITY OF UNCORRECTABLE ERROR

RAW DEFECT EVENT RATE (DEFECT EVENTS PER BIT)	UNCORRECTABLE SECTOR EVENT RATE (UNCORRECTABLE SECTOR EVENTS PER BIT)
1.0E-5	1.4E-27
1.0E-4	3.8E-18

- MISCORRECTION PROBABILITY = 4.12E-8

Figure 98. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

224/OMTR

Figure 99. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

EDAC: RECOMMENDED CODE

INTERLEAVED RS CODE

R FAIRCHILD

HEADER FIELD

- USE REDUNDANCY CHECK CODE

- GENERATOR POLYNOMIAL OF DEGREE K OVER GF(2)

- DETECTS ALL ERRORS OF LENGTH K BITS OR LESS

Figure 100. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

EDAC: RECOMMENDED CODE
INTERLEAVED RS CODE

FAIRCHILD

IMPLEMENTATION

● HARDWARE

- COMMERCIALLY AVAILABLE IC WITH MIL VERSION EXPECTED

- USED IN CODE GENERATION AND INTERLEAVING

- IN DECODER, HARDWARE USED FOR SYNDROM COMPUTATION

- BUFFER BETWEEN DEVICE AND HOST HAS CAPACITY OF AS
  MUCH AS ONE TRACK

- TRANSFER FROM DEVICE TO BUFFER AND BUFFER TO
  HOST IS ASYNCHRONOUS

- ERRORS ARE CORRECTED BEFORE SECTORS ARE SENT TO HOST

- BUFFER IS MEMORY MAPPED

<u>Figure 101</u>. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
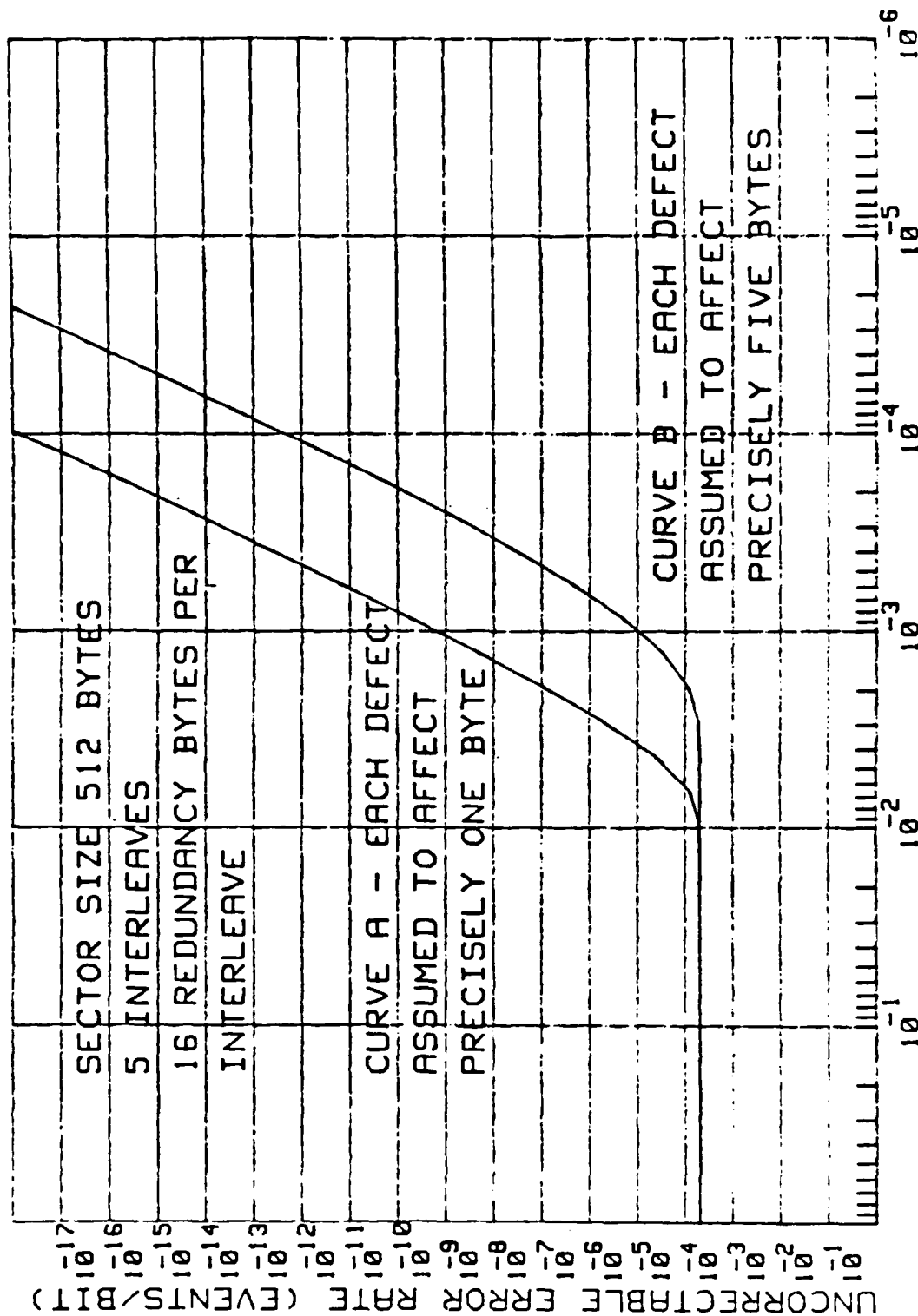Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

EDAC: RECOMMENDED CODE
INTERLEAVED RS CODE

IMPLEMENTATION

● SOFTWARE

- IMPLEMENTS REMAINING STEPS OF DECODING ALGORITHM

- SOFTWARE AVAILABLE FOR Z8 AND 8088 MICROPROCESSORS

- PROCESSING TIME

CORRECTION TIMES (MICROSECONDS)

# OF ERRORS	Z8 @ 12 MHZ	8088 @ 8 MHZ
0	5	20
1	140	140
2	340	460
3	2,000	4,000
4	3,300	5,300
5	4,400	8,100
6	5,500	10,800
7	6,600	13,500
8	7,600	16,000

Figure 102. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

Ⅱ FAIRCHILD

EDAC: TRACK FORMAT CONSIDERATIONS

● NEED ERROR TOLERANCE IN TRACK FORMAT

● SPECIAL FIELDS AND MARKS MUST BE ERROR-TOLERANT:

- SYNCH FIELDS AND MARKS
- HEADER FIELDS
- SECTOR AND INDEX MARKS

Figure 103. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

EDAC: TRACK FORMAT CONSIDERATIONS

SYNCHRONIZATION

⬛ FAIRCHILD

- DEVICE MUST BE TOLERANT OF DEFECTS THAT FALL WITHIN SYNCH FIELDS AND MARKS

- SELECT ERROR-TOLERANT SYNCH MARKS

- REPLICATE SYNCH MARKS WITH SOME NUMBER OF BYTES IN BETWEEN

- DESIGN CONTROLLER SUCH THAT NO SINGLE SYNCH MARK IS REQUIRED TO BE DETECTED

- DESIGN PLL SUCH THAT IT CAN FLYWHEEL THROUGH MAXIMUM DEFECT LENGTH

- USE TIMING WINDOWS IN SYNCH MARK DETECTION TO MINIMIZE PROBABILITY OF FALSE DETECTION

- USE RESYNCH FIELDS THAT ARE TOLERANT TO ERRORS

Figure 104. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

EDAC: TRACK FORMAT CONSIDERATIONS

HEADERS

- USE SEVERAL CONTIGUOUS REPLICAS OF THE HEADER

- USE TRACK ORIENTATION TO GENERATE HEADER INFORMATION WHEN HEADER IS IN ERROR

- ELIMINATE HEADER BY PLACING ADDRESS IN DATA FIELD

Figure 105. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
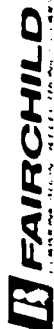
OMTR/231

FAIRCHILD
SPACE AND DEFENSE SYSTEMS

EDAC: TRACK FORMAT CONSIDERATIONS
DEFECT MANAGEMENT

● RETIRE SECTORS WITH A SPECIFIED AMOUNT OF DEFECTS

● USE DYNAMIC DEFECT MANAGEMENT TO FLAG MARGINAL
  SECTORS OR SECTORS TO BE RETIRED

Figure 106. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
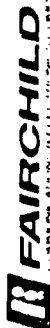Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

232/OMTP

FAIRCHILD

ERROR MANAGEMENT

● DEFINITION - THE ORDERLY HANDLING OF STATIC AND DYNAMIC ERRORS
  THAT OCCUR WHEN TRANSFERRING INFORMATION TO OR
  FROM THE OPTICAL DISK

● PROBLEMS MOST LIKELY TO OCCUR IN OPTICAL DISK SYSTEMS

  - PHYSICAL MEDIA DEFECTS
  - READ/WRITE ERRORS
  - LOSS OF SYNCHRONIZATION THROUGH LARGE DEFECTS
  - FALSE SYNC MARK DETECTIONS
  - MISSING SYNC MARKS
  - DEFECTIVE SECTORS
  - MISSING OR INCORRECT FORMATS
  - DEFECTIVE HEADER FIELDS
  - COMMAND AND PROTOCOL ERRORS
  - TIME-OUTS

Figure 107. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

ERROR MANAGEMENT - STRATEGIES

- PHYSICAL MEDIA DEFECTS
  - RETIRE SECTORS AT FORMAT TIME
  - RETIRE MEDIA IF EXCESSIVE DEFECTS OCCUR

- WRITE DATA ERRORS
  - IF SMALL NUMBER OF ERRORS THEN USE CORRECTION METHODS
  - IF EXCESSIVE ERRORS THEN REWRITE SECTOR TO ALTERNATE LOCATION

- READ DATA ERRORS
  - REREAD SECTOR
  - USE CORRECTION METHODS

- MAINTAINING SYNC THROUGH LARGE DEFECTS
  - USE SOME CRITERIA (I.E., RUN LENGTH VIOLATION, LOSS OF SIGNAL
    AMPLITUDE, ETC.) TO SHUT OFF UPDATING OF THE PLL'S FREQUENCY
    AND PHASE MEMORY

- FALSE SYNC MARK DETECTION
  - INCREASE MARK WIDTHS
  - INCREASE MARK FREQUENCY
  - QUALIFY MARK WITH A TIMING WINDOW

- MISSING SYNC, INDEX, AND SECTOR MARKS
  - USE ERROR TOLERANT MARKS
  - USE REDUNDANT MARKS
  - MAKE CONTROLLER INSENSITIVE TO THEIR LOSS.

Figure 108. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

ERROR MANAGEMENT - STRATEGIES (CONT'D.)

FAIRCHILD

- TIMEOUT ERRORS (WATCHDOG, SEEK TIMEOUT)
  - REPORT ERRORS TO FMS

- COMMAND OR PROTOCOL ERRORS
  - REPORT ERRORS TO FMS

- DEFECTIVE HEADER FIELD
  - USE RELATIVE SECTOR POSITION ON TRACK TO DETERMINE SECTOR ADDRESS
  - RETIRE SECTOR AND REWRITE TO ALTERNATE LOCATION
  - NEVER STORE VITAL INFORMATION IN HEADER FIELD THAT IS SENSITIVE TO LOSS

Figure 109. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

MODULATION CODES

PURPOSE

- METHOD FOR MAPPING DATA OR MODULATING DATA ONTO STORAGE MEDIA

SELECTION CRITERIA

- EFFICIENCY - NUMBER OF STORED BITS PER LASER MARK

- SELF-CLOCKING - ABILITY TO EXTRACT CLOCK FROM DATA TRANSITIONS. CODE MUST BE ABLE TO ACQUIRE AND HOLD SYNCH THROUGH DEFECTS

- READ RESOLUTION - MEASURE OF DETECTION ACCURACY GIVEN IN TERMS OF TIMING WINDOW SIZE

- INTERSYMBOL INTERFERENCE - INTERFERENCE BETWEEN ADJACENT SYMBOLS

- BANDWIDTH - OVERALL CHARACTERIZATION OF CODE IN FREQUENCY DOMAIN. NO OR SMALL DC COMPONENT AND NARROW BANDWIDTH ARE DESIRED

- CIRCUIT COMPLEXITY AND AVAILABILITY - TYPE, SIZE AND COST OF CIRCUIT REQUIRED TO IMPLEMENT CODE

Figure 110. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

MODULATION CODES

POSSIBLE CODE CHOICE

- EFM   -   EIGHT OF FOURTEEN MODULATION.A (2,10) RLL CODE. USED
             FOR CD'S AND CD-ROM'S.

- TOON -   TWO OUT OF NINE. A NON SELF-CLOCKING BLOCK CODE WITH A
             HIGH LEVEL OF LARGE AMPLITUDE AND OFFSET VARIATION
             INSENSITIVITY. REQUIRES IMBEDDED CLOCKING. USED BY OSI
             FOR 1 GB 12" W/O OPTICAL DRIVE.

- MFM   -   MODIFIED FREQUENCY MODULATION. A (1,3) RLL CODE. USED BY
             ISI FOR 100 MB 5 1/4" W/O OPTICAL DRIVE.

- 3Ø (1,7) - A (1,7) RLL CODE. USED BY RCA FOR 1.25 GB 14" W/O
             WIDEBAND OPTICAL DISK DATA ACQUISITION RECORDER.

- (2,7) - THE MOST WIDELY USED RLL CODE: KODAK, HITACHI, AND OTHERS
             ARE USING IT FOR BOTH W/O AND ERASABLE OPTICAL DRIVES IN
             THE 3.5" TO 14: FORM FACTOR RANGE.

Figure 111.   "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

FAIRCHILD

FILE MANAGEMENT

Figure 112. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

FMS DEFINITION

- GIVES USER CAPABILITY TO CREATE NAME SPACES (FILES)

- RESPONSIBLE FOR STORING, RETRIEVING AND MANAGING DATA STORED IN MASS MEMORY

  - MAPS LOGICAL FILES INTO PHYSICAL LOCATIONS

  - ALLOCATES, DEALLOCATES, AND ADMINISTERS MASS STORAGE EFFECTIVELY

Figure 113. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/239

PROBLEMS OF OPTICAL DISK TECHNOLOGY FOR FILE MANAGEMENT **FAIRCHILD**
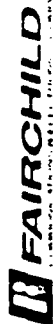
- LARGE WRITE-ONCE, READ MOSTLY MEMORY

  - OPTIMIZE DIRECTORY, FILE STRUCTURE FOR EASE OF READING AT EXPENSE OF WRITE TIME

  - DIRECTORY SPACE VS. FILE SPACE (MANY SMALL FILES/FEW LARGE FILES, READ-ONLY FILES/READ-WRITE FILES, PRE-ALLOCATED SPACE/DYNAMICALLY ALLOCATED SPACE)

  - STORAGE OF DIRECTORY, FILE UPDATES (PRE-ALLOCATED SPACE/DYNAMICALLY ALLOCATED SPACE, RELATING UPDATE TO PREDECESSOR FOR RETRIEVAL)

  - IDENTIFYING WRITTEN DATA AS CURRENT OR OUT-OF-DATE

- LONG AVERAGE SEEK TIMES COMPARED TO MAGNETIC MEDIA

  - ARRANGE DIRECTORY AND FILES SO AS TO MINIMIZE COARSE SEEKS AND ROTATIONAL DELAY

  - LOGICAL VERSUS PHYSICAL FILE ACCESS CONSIDERATIONS (SEQUENTIAL, RANDOM, INDEXED SEQUENTIAL ACCESS)

- SECTOR (512 BYTES) IS SMALLEST ADDRESSABLE UNIT ON DISK

  - ANY CHANGE IN SECTOR CONTENTS REQUIRES REWRITING ENTIRE SECTOR

  ⟹ RECORD (LOGICAL UNIT) STORED AS SECTOR (PHYSICAL UNIT) FOR EFFICIENCY

Figure 114. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
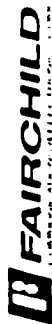
240/OMTR

FAIRCHILD

GOALS

● MINIMIZE OVERHEAD

  - FMS PROCESSING TIME
  - SPACE NEEDED FOR STORING FMS DATA (E.G., DIRECTORY)
  - COMMUNICATION BETWEEN HOST AND FMS

● MAXIMIZE THROUGHPUT FOR HOST

  - MINIMIZE COARSE SEEKS (~80 MS)
  - MAXIMIZE USE OF SEQUENTIAL TRACKS/SECTORS
  - MINIMIZE TRANSMISSION DELAYS

● PERMIT USE WITH REMOVABLE AS WELL AS FIXED MEDIA
  ⇒ MAINTAIN DIRECTORY ON OPTICAL DISK MEDIA

● EFFICIENT USE BY VARIETY OF APPLICATIONS

  - SMALL NUMBER OF LARGE FILES (E.G., TERRAIN MAPS)
  - NUMEROUS FILES OR VERSIONS OF SAME FILES (E.G., DATA EXTRACTION, DATA RECORDING)
  - READ-MOSTLY APPLICATIONS (E.G., MAPS)
  - WRITE-MOSTLY APPLICATIONS (E.G., DATA RECORDING)
  - READ/WRITE APPLICATIONS

Figure 115. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

GOALS (CONTINUED)

FAIRCHILD

- TRANSITION TO READ/WRITE OPTICAL DISK TECHNOLOGY TRANSPARENT TO HOST

  - IDEALLY NO CHANGE REQUIRED TO HOST SOFTWARE TO INTERFACE
    WITH/USE WORM OR RW OPTICAL DISK

- FMS INTERNAL TO ODM AS AN ORDERING OPTION

  - APPLICATION DEPENDENT

    - IF MORE EFFICIENT FOR HOST TO EMBED KNOWLEDGE OF FILE
      STRUCTURE AND LOCATION IN APPLICATION SOFTWARE, CUSTOMER
      SHOULD NOT NEED TO PURCHASE ODM FMS (E.G., FOR CERTAIN
      MAP DATA BASES WHERE FILE = ODM TRACK)

    - HOST INTERFACES WITH ODM ON CONTROLLER LEVEL

Figure 116. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown
MD 20874-1182.

⊞ FAIRCHILD

RECOMMENDED FMS APPROACH

• FILES CONSIST OF ONE OR MORE TRACKS

• TWO FILES CANNOT CO-EXIST ON SAME TRACK

• FILES ALLOCATED SEQUENTIAL SECTORS UNTIL A DIRECTORY SECTOR DETECTED

• FILE OPERATIONS:

  ADD FILE/DELETE FILE/UPDATE FILE (CREATE/EXTEND)

• DIRECTORY CREATED IN NON-VOLATILE SCM DURING POWER UP

  (UPDATE ODM DURING POWER-DOWN)

• RECORD OCCUPIES ONE SECTOR

  (SMALLEST ADDRESSABLE ENTITY ON DISK)

• RECORD OPERATIONS:

  ADD RECORD/CHANGE RECORD/DELETE RECORD

Figure 117. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

SYSTEM ARCHITECTURE

Figure 118. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
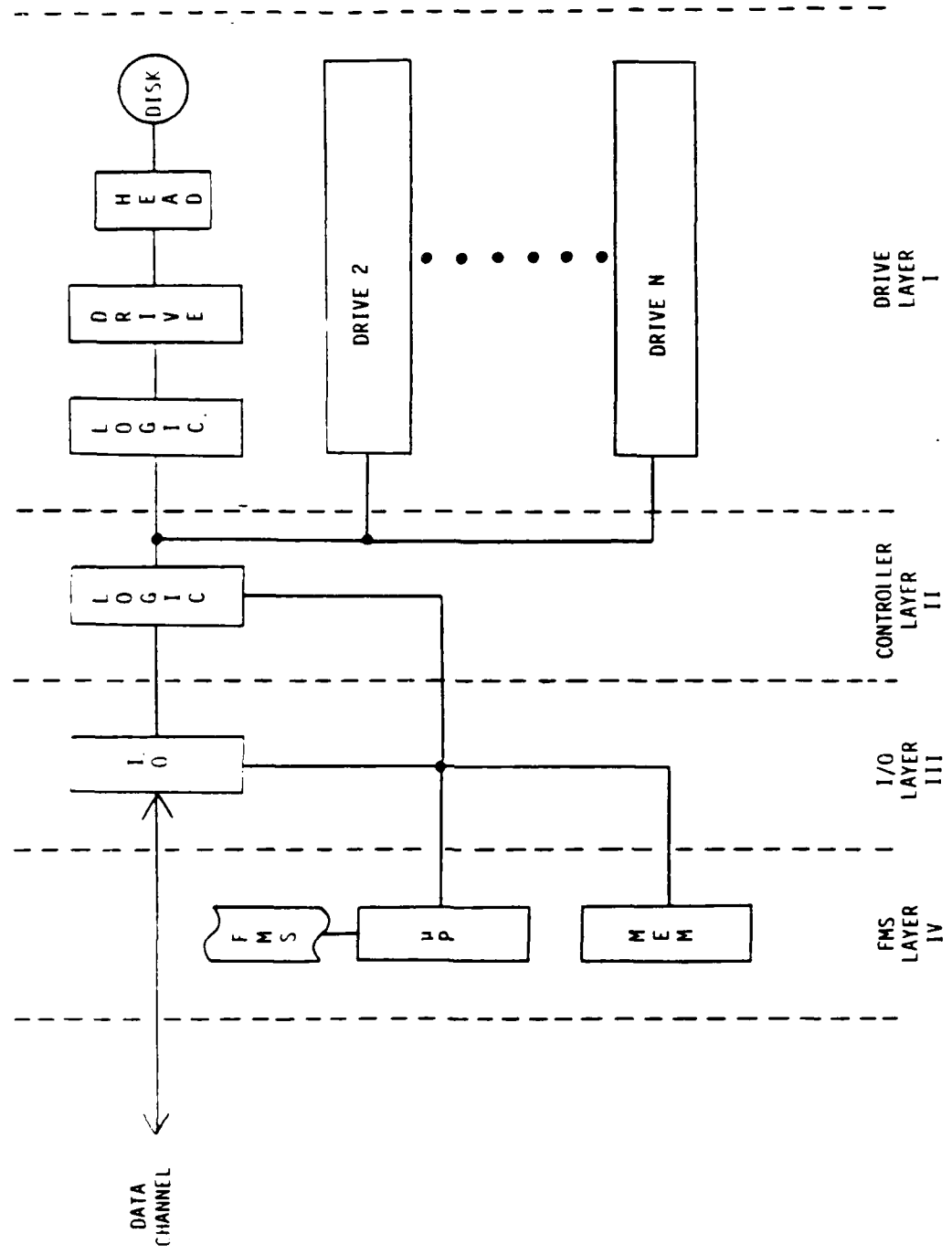
OPTICAL DISK SYSTEM DIAGRAM

FAIRCHILD

Figure 119. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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SYSTEM ARCHITECTURE - FUNCTIONAL DESCRIPTION

● LAYER 1 - WORM DRIVE

- READ/WRITE INTERFACE TO OPTICAL MEDIA
- MEDIA SPIN CONTROL
- HEAD MOTION AND POSITION CONTROL
- DATA ENCODING/DECODING (MFM, RLL2-7, ETC.)
- ESDI INTERFACE TO CONTROLLER

● LAYER 2 - CONTROLLER

- ESDI INTERFACE TO DRIVE
- COMMAND AND DATA INTERFACE
- ERROR DETECTION AND CORRECTION
- ERROR MANAGEMENT AT THE SECTOR LEVEL
- INTERFACE TO FILE MANAGEMENT SYSTEM
- SECTOR BUFFERING

● LAYER 3 - I/O INTERFACES

- PROVIDES DATA PATH FROM OPTICAL DISK UNIT TO HOST
- SUPERVISES PROTOCOL BETWEEN HOST AND CONTROLLER

● LAYER 4 - FRONT END PROCESSOR

- FILE MANAGEMENT SYSTEM
- ERROR MANAGEMENT AT THE FILE LEVEL
- OPERATING SYSTEM
- DATA COMPRESSION/DECOMPRESSION
- INTERFACE BETWEEN HOST AND CONTROLLER

Figure 120. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

CONTROLLER - DESIGN FEATURES

- USES ESDI DISK INTERFACE

- CAN WORK WITH OPTICAL OR MAGENTIC DISK DRIVES

- DATA RATES UP TO 10 MBITS/SECOND

- BUILT IN ERROR MANAGEMENT SYSTEM

- HARD OR SOFT SECTORED DISK FORMATS

- ONE FULL TRACK SECTOR BUFFER

- INTERLEAVED REED-SOLOMON EDAC

- USER SELECTABLE INTERLEAVE FACTOR (1-6)

- CAN SUPPORT UP TO SEVEN DRIVES

- CAN WORK WITH OR WITHOUT THE FRONT END PROCESSOR CARD

- USER PROGRAMMABLE SEQUENCER FOR CHANGING DISK FORMATS

- CAN HANDLE POST DATA FIELDS FOR SECTOR LINKAGE

Figure 121. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

OMTR/247

R FAIRCHILD

FRONT END PROCESSOR - DESIGN FEATURES
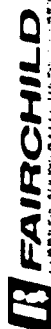
- CHOICE OF THREE HIGH PERFORMANCE 16-BIT CPUs

  - M8088 (PLM/86)
  - Z8000 (JOVIAL, ADA)
  - F9450 (MIL-STD-1750ISA)

- CONTAINS LOCAL PROGRAM AND SYSTEM MEMORY (ROM, RAM)

- HAS ON-BOARD NON-VOLATILE MEMORY FOR SAVING SYSTEM PARAMETERS, INDEXES, DIRECTORIES, ETC., DURING POWER DOWN

- CONTAINS OPTIONAL FILE MANAGEMENT SYSTEM

Figure 122. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications And Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
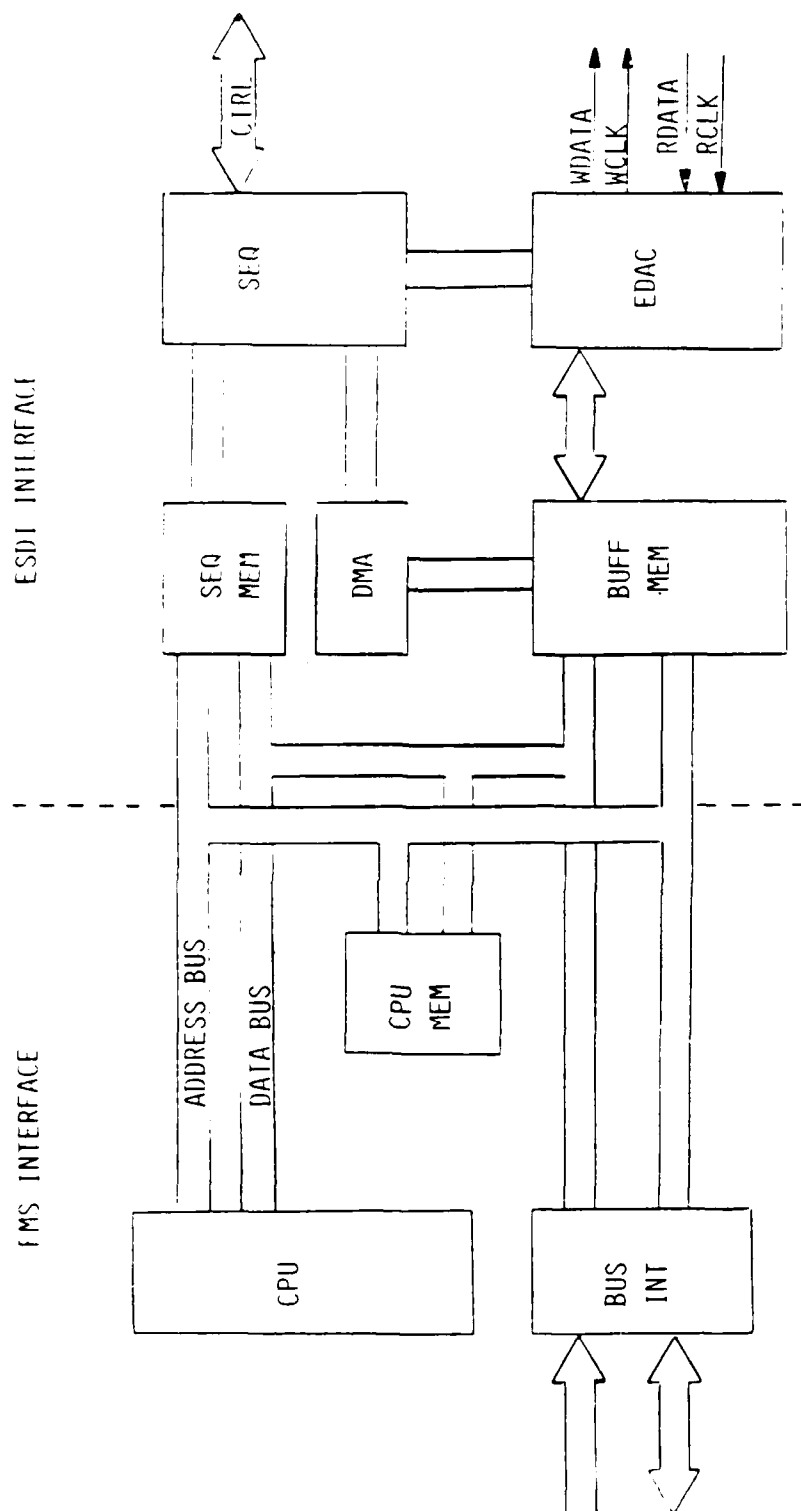
248/OMTR

OPTICAL DISK CONTROLLER - BLOCK DIAGRAM

Figure 123. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

FAIRCHILD

I/O MILITARY INTERFACES

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FAIRCHILD

HOST INTERFACES

- MIL-STD-1553B

  - ACCEPTED AND WIDELY USED BY AIR FORCE, NAVY, AND ARMY
  - HALF DUPLEX OPERATION
  - PARTY LINE, SUPPORTS UP TO 32 TERMINALS
  - SERIAL BUS STRUCTURE
  - COMMAND/RESPONSE PROTOCOL
  - MESSAGE SYNCHRONOUS, BIT ASYNCHRONOUS
  - 32 WORD MESSAGE LENGTH
  - 1 MHz DATA RATE

ADVANTAGES

- WIDELY USED
- GOOD AS CONTROL BUS

DISADVANTAGES

- SMALL MESSAGE LENGTH
- LOW DATA RATE

Figure 125. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.
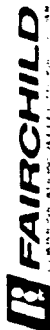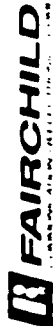
HOST INTERFACES (CONT'D.)

● MIL-STD-1773

- STATUS: NOT YET ACCEPTED, STILL IN COMMITTEE

- FIBER OPTIC VERSION OF MIL-STD-1553B

- DUAL DATA RATE: 1 MHZ FOR EXSITING SYSTEMS

  10 MHZ FOR NEW SYSTEMS

ADVANTAGES

- HIGH DATA RATE

DISADVANTAGES

- NOT YET ESTABLISHED

Figure 126. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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HOST INTERFACES (CONT'D.)

FAIRCHILD

● MIL-STD-1379 (NTDS)

- STATUS: USED BY NAVY ABOARD SHIPS AND AIRCRAFT

- THREE POINT-TO-POINT MODES

A. PARALLEL (SLOW) - 41.6 KWORDS/SEC
B. PARALLEL (FAST) - 250 KWORDS/SEC
C. SERIAL - 10 MBIT/SEC

- SYNCHRONOUS PARALLEL OPERATION

- MESSAGE SYNCHRONOUS, BIT ASYNCHRONOUS

- VARIABLE MESSAGE SIZE, SYSTEM DEPENDENT

- VARIABLE WORD SIZE, SYSTEM DEPENDENT

ADVANTAGES

- HIGH DATA RATE

- VARIABLE POROTCOL

DISADVANTAGES

- POINT-TO-POINT ARCHITECTURE

Figure 127. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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HOST INTERFACES (CONT'D.)

B FAIRCHILD

● HIGH SPEED DATA BUS (HSDB)

- STATUS: IN DEVELOPMENT BY AIR FORCE/SAE

- HALF DUPLEX

- PARTY LINE, 128 TERMINALS

- TOKEN PASSING BUS STRUCTURE

- UP TO 4 KWORD MESSAGE SIZE

- 20 TO 100 MHZ DATA RATE (30 MHZ TYP)

- FIBER OPTIC OR WIRE OPERATION

<u>ADVANTAGES</u>

- HIGH DATA RATE

- MULTI USER BUS

- LARGE MESSAGE SIZE

<u>DISADVANTAGES</u>

-- NOT YET DEVELOPED

<u>Figure 128.</u> "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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NUCLEAR RADIATION

Figure 129. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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NUCLEAR RADIATION HARDENING ANALYSIS
NADC STUDY

II *FAIRCHILD*

ACTIVITY

- DETERMINATION OF RADIATION LEVELS

- TARGETING OF OMS HARDWARE FOR ANALYSIS

- SCOPE AND METHODS OF TESTING AND ANALYSIS

- SYSTEM GENERATED EMP

TARGETING OF OMS HARDWARE

- OMS HARDWARE

  - ELECTRONICS
  - SERVO/MECHANICAL
  - OPTICAL (DISKS, HEADS)

- RADIATION HARDENING TECHNOLOGY DEVELOPED

  - ELECTRONICS
  - SERVO/MECHANICAL

- CONCLUSION: RADIATION ANALYSIS FOR OPTICAL HARDWARE ONLY

Figure 130. "Optical Memory System Study Presentation." Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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DETERMINATION OF RADIATION LEVELS

● LEVEL CRITERION: S-110 "OPTIMAL NUCLEAR RADIATION CRITERIA FOR
  AERONAUTICAL SYSTEMS"; VHSIC OBJECTIVES;
  PRESENT SYSTEM REQUIREMENTS

LEVELS (BASED ON CRITERION)

● TOTAL DOSE: 1 TO 10 KRAD (SI)

● DOSE RATE: 10^8 TO 10^9 RAD(SI)/S @ 20NS

● NEUTRON FLUENCE: 10^{12} TO 10^{13} N/CM^2

● EMP CONSISTENT WITH ABOVE LEVELS

Figure 131. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
MD 20874-1182.

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FAIRCHILD

SCOPE AND METHODS OF TESTING AND ANALYSIS
DISKS

● SCOPE

- BOTH WORM AND M-O DISKS TO BE TESTED

- TOTAL DOSE AND NEUTRON FLUENCE TO BE PERFORMED

- DOSE RATE SYSTEM PERFORMANCE DIFFICULT (DRIVE MUST OPERATE DURING EXPOSURE)

● METHOD

- EVALUATE SYSTEM PERFORMANCE (DISK/DRIVE ERROR RATES) FOR VARIOUS EXPOSURES

- EXPOSE DISKS OVER TOTAL DOSE RANGE

- EXPOSE DISKS OVER NEUTRON FLUENCE RANGE

Figure 132. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications, and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

SCOPE AND METHODS OF TESTING AND ANALYSIS

HEADS
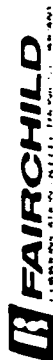
● SCOPE

- BOTH WORM AND M-O HEADS TO BE EVALUATED

- DIFFICULT TO OBTAIN SEVERAL HEADS (NECESSARY FOR RADIATION TESTING)

- RADIATION EFFECTS DATA AVAILABLE FOR OPTICS

- HEAD ANALYSIS PERFORMED BY MATERIALS STUDY

● METHOD

- IDENTIFY OPTICAL COMPONENTS/MATERIALS IN HEADS

- PERFORM RADIATION MATERIALS ANALYSIS

Figure 133. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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FAIRCHILD

NAVSEA APPLICATIONS

Figure 134. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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ARCHITECTURAL STUDY - CONTROL DATA CORPORATION   **⚇ FAIRCHILD**

● INVESTIGATE APPLICATION OF OPTICAL DISK TECHNOLOGY TO
  EXISTING COMPUTER MEMORY COMPLEXES

● DEFINE OVERALL COMPUTER/MEMORY SYSTEM REQUIREMENTS
  FOR BOTH HARDWARE AND SOFTWARE

● DEFINITION OF PRESENT SYSTEM

● DEFINITION OF ARCHITECTURE BASED UPON "PRACTICAL"
  OPTICAL DISK TECHNOLOGY DEFINED IN OMS STUDY

  - FUNCTIONAL DESCRIPTION   DERIVE DISK DRIVE REQUIREMENTS
  - PERFORMANCE REQUIREMENT
  - INTERFACE PARAMETERS

Figure 135. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
Communications and Electronics, 20301 Century Boulevard, Germantown,
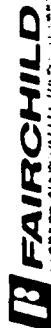MD 20874-1182.

FAIRCHILD

SYSTEM DECISIONS/TRADE-OFFS

Figure 136. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

B FAIRCHILD

SYSTEM DEVELOPMENT DECISIONS

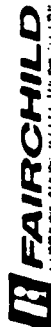- SYSTEM TECHNOLOGY

    - WRITE ONCE

    - ERASEABLE

    - COMMON

- TRANSPORTABILITY LEVEL

    - MEDIA

    - CARTRIDGE

    - DRIVE

Figure 137. "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown, MD 20874-1182.

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SYSTEM CONCLUSIONS

:: FAIRCHILD

WRITE ONCE SYSTEM   ERASABLE SYSTEM

● REQUIRED DEVELOPMENT PROGRAMS   ● REQUIRED DEVELOPMENT PROGRAMS

  - W/O MEDIA   - ERASABLE MEDIA

  - OPTICAL HEADS   - OPTICAL HEADS (MORE COMPLEX)

  - SERVO MECHANISMS   - SERVO MECHANISMS (MORE COMPLEX)

● SHORTEST SCHEDULE TO PRODUCTION   ● LONGER SCHEDULE TO PRODUCTION

● LOWEST COST   ● HIGH COST

● INTERIM SYSTEM   ● ULTIMATE SYSTEM

NOTE: COMMON DRIVE CAN BE REALIZED WITH ADDITION OF W/O MEDIA DEVELOPMENT

Figure 138. "Optical Memory System Study Presentation," Tim Rogers, Fairchild
             Communications and Electronics, 20301 Century Boulevard, Germantown,
             MD 20874-1182.

⚡ FAIRCHILD

TRANSPORTABILITY LEVEL

ASSUMPTION - OPTICAL COMPONENTS MUST BE SEALED FROM ENVIRONMENT

<u>CHOICE</u>

● SEAL COMPLETE DRIVE AND REMOVE AS A SUBASSEMBLY

● DEVELOP A SEALED CARTRIDGE THAT CONTAINS ELEMENTS OF SPIN MOTOR ASSEMBLY

● TRANSPORT MEDIA ONLY, BUT DEVELOP DRIVE SYSTEM WITH ENVIRONMENTAL CONTROL SYSTEM

<u>Figure 139.</u> "Optical Memory System Study Presentation," Tim Rogers, Fairchild Communications and Electronics, 20301 Century Boulevard, Germantown MD 20874-1182.

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END

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DTIC